Application Interfaces

- I^2C-compatible slave with support for Standard mode (up to 100 kHz), Fast mode (up to 400 kHz)
- Interrupt to indicate when a message is available
- SPI Debug Interface to read the real-time raw data for tuning and debugging purposes

Power Supply

- Digital (Vdd) 3.3 V nominal
- Digital I/O (VddIO) 3.3 V nominal

Package

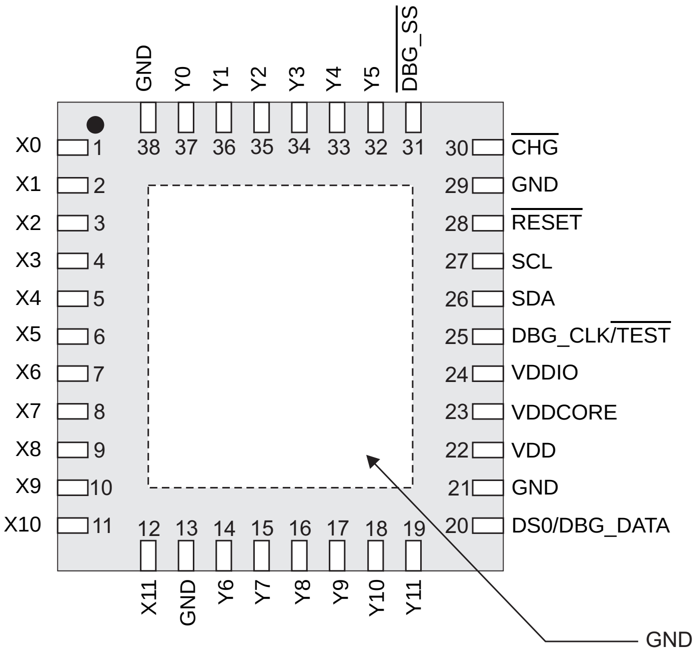
- 38-pin XQFN 4 × 4 × 0.35 mm, 0.35 mm pitch

Operating Temperature

- –40°C to +85°C

PIN CONFIGURATION

Pin Configuration – 38-pin XQFN



Top View

TABLE 0-1: PIN LISTING – 38-PIN XQFN

Pin	Name	Type	Supply	Description	If Unused...
1	X0	S	Vdd	X line connection	Leave open
2	X1	S	Vdd	X line connection	Leave open
3	X2	S	Vdd	X line connection	Leave open
4	X3	S	Vdd	X line connection	Leave open
5	X4	S	Vdd	X line connection	Leave open
6	X5	S	Vdd	X line connection	Leave open
7	X6	S	Vdd	X line connection	Leave open
8	X7	S	Vdd	X line connection	Leave open
9	X8	S	Vdd	X line connection	Leave open
10	X9	S	Vdd	X line connection	Leave open
11	X10	S	Vdd	X line connection	Leave open
12	X11	S	Vdd	X line connection	Leave open
13	GND	P	–	Ground	–
14	Y6	S	Vdd	Y line connection	Leave open
15	Y7	S	Vdd	Y line connection	Leave open
16	Y8	S	Vdd	Y line connection	Leave open
17	Y9	S	Vdd	Y line connection	Leave open
18	Y10	S	Vdd	Y line connection	Leave open
19	Y11	S	Vdd	Y line connection	Leave open
20	DS0	S	Vdd	Driven Shield signal; used as guard track between X/Y signals and ground	Leave open
	DBG_DATA	O		Debug Data	
21	GND	P	–	Ground	–
22	VDD	P	–	Digital and analog power	–
23	VDDCORE	P	–	Digital core power	–
24	VDDIO	P	–	Digital IO interface power	–
25	DBG_CLK	O	VddIO	Debug Clock	Pull up to VddIO
	$\overline{\text{TEST}}$	–		Reserved for factory use	
26	SDA	OD	VddIO	Serial Interface Data	–
27	SCL	OD	VddIO	Serial Interface clock	–
28	$\overline{\text{RESET}}$	I	VddIO	Reset low. Connection to host system is recommended	Pull up to VddIO
29	GND	P	–	Ground	–
30	$\overline{\text{CHG}}$	OD	VddIO	State change interrupt Note: Briefly set (~100 ms) as an input after power-up/ reset for diagnostic purposes	Pull up to VddIO
31	$\overline{\text{DBG\_SS}}$	O	Vdd	Debug SS line	Leave open
32	Y5	S	Vdd	Y line connection	Leave open
33	Y4	S	Vdd	Y line connection	Leave open
34	Y3	S	Vdd	Y line connection	Leave open
35	Y2	S	Vdd	Y line connection	Leave open
36	Y1	S	Vdd	Y line connection	Leave open
37	Y0	S	Vdd	Y line connection	Leave open

TABLE 0-1: PIN LISTING – 38-PIN XQFN (CONTINUED)

Pin	Name	Type	Supply	Description	If Unused...
38	GND	P	–	Ground	–
Pad	GND	P	–	Exposed pad must be connected to GND	–

Key:

I	Input only	O	Output only	I/O	Input or output
OD	Open drain output	P	Ground or power	S	Sense pin

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1.0 OVERVIEW OF MXT144U

The Microchip maXTouch family of touch controllers brings industry-leading capacitive touch performance to customer applications. The mXT144U features the latest generation of Microchip adaptive sensing technology that utilizes a hybrid mutual and self capacitive sensing system in order to deliver unparalleled touch features and a robust user experience.

- **Patented capacitive sensing method** – The mXT144U uses a unique charge-transfer acquisition engine to implement Microchip's patented capacitive sensing method. Coupled with a state-of-the-art CPU, the entire touchscreen sensing solution can measure, classify and track a number of individual finger touches with a high degree of accuracy in the shortest response time.
- **Capacitive Touch Engine (CTE)** – The mXT144U features an acquisition engine, which uses an optimal measurement approach to ensure almost complete immunity from parasitic capacitance on the receiver input lines. The engine includes sufficient dynamic range to cope with anticipated touchscreen self and mutual capacitances, which allows great flexibility for use with the Microchip proprietary sensor pattern designs. One- and two-layer ITO sensors are possible using glass or PET substrates.
- **Touch detection** – The mXT144U allows for both mutual and self capacitance measurements, with the self capacitance measurements being used to augment the mutual capacitance measurements to produce reliable touch information.

  When self capacitance measurements are enabled, touch classification is achieved using both mutual and self capacitance touch data. This has the advantage that both types of measurement systems can work together to detect touches under a wide variety of circumstances.

  During idle mode, the device performs low-power touch detection scans. When a touch is detected, the device starts performing active touch resolution scans.

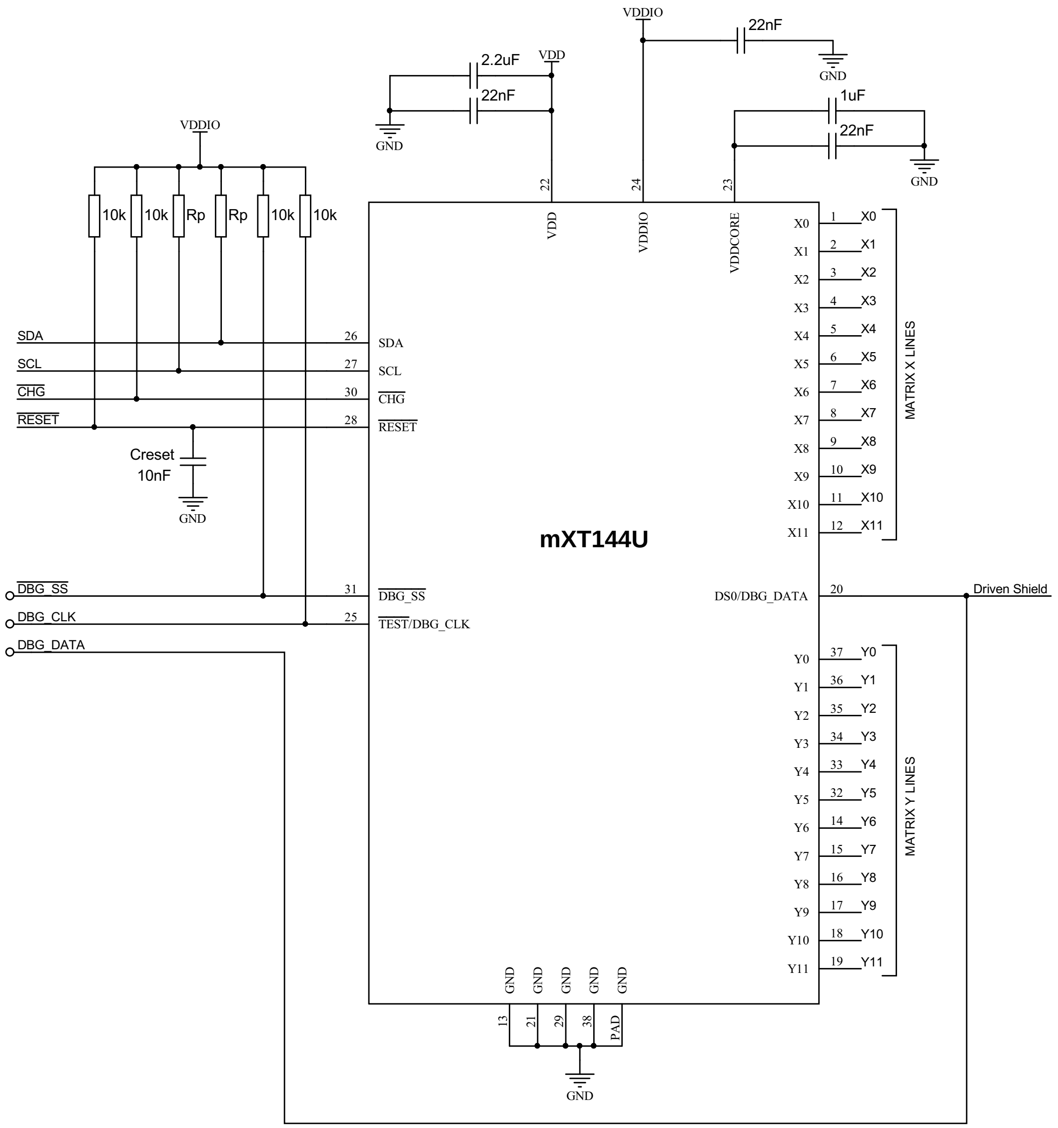
  The system may be configured for different types of default measurements in both idle and active modes. For example, the device may be configured for Mutual Capacitance Touch as the default in idle mode and Self Capacitance Touch as the default in active mode. Note that other types of scans (such as other types of self capacitance scans) may also be made depending on configuration.

  Mutual capacitance touch data is used wherever possible to classify touches as this has greater granularity than self capacitance measurements and provides positional information on touches. For this reason, multiple touches can only be determined by mutual capacitance touch data. In Self Capacitance Touch Default mode, if the self capacitance touch processing detects multiple touches, touchscreen processing is skipped until mutual capacitance touch data is available.

  Self capacitance measurements allow for the detection of single touches in extreme cases, such as single thick glove touches, when mutual capacitance touch detection alone may miss touches.
- **Display Noise Cancellation** – A combination of analog circuitry, hardware noise processing, and firmware that combats display noise without requiring additional listening channels or synchronization to display timing. This enables the use of shieldless touch sensor stacks, including touch-on-lens.
- **Noise filtering** – Hardware noise processing in the capacitive touch engine provides enhanced autonomous filtering and allows a broad range of noise profiles to be handled. The result is good performance in the presence of charger and LCD noise.
- **Processing power** – The main CPU has two powerful microsequencer coprocessors under its control consuming low power. This system allows the signal acquisition, preprocessing, postprocessing and housekeeping to be partitioned in an efficient and flexible way.
- **Interpreting user intention** – The Microchip hybrid mutual and self capacitance method provides unambiguous multitouch performance. Algorithms in the mXT144U provide optimized touchscreen position filtering for the smooth tracking of touches, responding to a user's intended touches while preventing false touches triggered by ambient noise, conductive material on the sensor surface, such as moisture, or unintentional touches from the user's resting palm or fingers.

2.0 SCHEMATIC

2.1 38-pin XQFN



See Section 2.2 “Schematic Notes”

2.2 Schematic Notes

2.2.1 POWER SUPPLY

The sense and I/O pins are supplied by the power rails on the device as listed in Table 0-1. This information is also indicated in “Pin configuration”.

Table 0-1. Power Supply for Sense and I/O Pins

Power Supply	Pins
Vdd	X sense pins, Y sense pins, DS0/DBG_DATA, DBG_SS
VddIO	RESET, SDA, SCL, CHG, DBG_CLK/TEST

2.2.2 DECOUPLING CAPACITORS

All decoupling capacitors must be X7R or X5R and placed less than 5 mm away from the pins for which they act as bypass capacitors. Pins of the same type can share a capacitor provided no pin is more than 10 mm from the capacitor.

The schematics on the previous pages show the optimum capacitors required. The parallel combination of capacitors is recommended to give high and low frequency filtering, which is beneficial if the voltage regulators are likely to be some distance from the device (for example, If an active tail design is used). Note that this requires that the voltage regulator supplies for Vdd and VddIO are clean and noise free. It also assumes that the track length between the capacitors and on-board power supplies is less than 50 mm.

The number of base capacitors can be reduced if the pinout configuration means that sharing a bypass capacitor is possible (subject to the distance between the pins satisfying the conditions above and there being no routing difficulties).

2.2.3 PULL-UP RESISTORS

The pull-up resistors shown in the schematic are suggested typical values and may be modified to meet the requirements of an individual customer design. This applies, in particular, to the I^2C pull-up resistors (see Section 2.2.5 “I^2C Interface”).

2.2.4 VDDCORE

VddCore is internally generated from the Vdd power supply. To guarantee stability of the internal voltage regulator, an external capacitor is required.

2.2.5 I^2C INTERFACE

The schematic shows pull-up resistors on the SDA and SCL lines. The values of these resistors depends on the speed of the I^2C interface. See Section 11.8 “I2C Specification” for details.

2.2.6 MULTIPLE FUNCTION PINS

Some pins may have multiple functions. In this case, only one function can be chosen and the circuit should be designed accordingly.

2.2.7 SPI DEBUG INTERFACE

The DBG_CLK, DBG_DATA and DBG_SS lines form the SPI Debug Interface. These pins should be routed to test points on all designs, such that they can be connected to external hardware during system development. See also Section 10.1 “SPI Debug Interface”.

The DBG_CLK, DBG_DATA and DBG_SS lines should not be connected to power or GND.

DBG_CLK is powered from VddIO; DBG_DATA is powered from Vdd. If VddIO and VDD are at different levels, a resistive voltage divider should be used to lower the higher voltage to match the lower one.

3.0 TOUCHSCREEN BASICS

3.1 Sensor Construction

A touchscreen is usually constructed from a number of transparent electrodes. These are typically on a glass or plastic substrate. They can also be made using non-transparent electrodes, such as copper or carbon. Electrodes are constructed from Indium Tin Oxide (ITO) or metal mesh. Thicker electrodes yield lower levels of resistance (perhaps tens to hundreds of Ω/square) at the expense of reduced optical clarity. Lower levels of resistance are generally more compatible with capacitive sensing. Thinner electrodes lead to higher levels of resistance (perhaps hundreds to thousands of Ω/square) with some of the best optical characteristics.

Interconnecting tracks can cause problems. The excessive RC time constants formed between the resistance of the track and the capacitance of the electrode to ground can inhibit the capacitive sensing function. In such cases, the tracks should be replaced by screen printed conductive inks (non-transparent) outside the touchscreen viewing area.

3.2 Electrode Configuration

The specific electrode designs used in Microchip touchscreens are the subject of various patents and patent applications. Further information is available on request.

The device supports various configurations of electrodes as summarized in Section 4.0 “Sensor Layout”.

3.3 Scanning Sequence

All nodes are scanned in sequence by the device. There is a full parallelism in the scanning sequence to improve overall response time. The nodes are scanned by measuring capacitive changes at the intersections formed between the first X line and all the Y lines. Then the intersections between the next X line and all the Y lines are scanned, and so on, until all X and Y combinations have been measured.

The device can be configured in various ways. It is possible to disable some nodes so that they are not scanned at all. This can be used to improve overall scanning time.

3.4 Touchscreen Sensitivity

3.4.1 ADJUSTMENT

Sensitivity of touchscreens can vary across the extents of the electrode pattern due to natural differences in the parasitic capacitance of the interconnections, control chip, and so on. An important factor in the uniformity of sensitivity is the electrode design itself. It is a natural consequence of a touchscreen pattern that the edges form a discontinuity and hence tend to have a different sensitivity. The electrodes at the far edges do not have a neighboring electrode on one side and this affects the electric field distribution in that region.

A sensitivity adjustment is available for the whole touchscreen. This adjustment is a basic algorithmic threshold that defines when a node is considered to have enough signal change to qualify as being in detect.

3.4.2 MECHANICAL STACKUP

The mechanical stackup refers to the arrangement of material layers that exist above and below a touchscreen. The arrangement of the touchscreen in relation to other parts of the mechanical stackup has an effect on the overall sensitivity of the screen. QMatrix technology has an excellent ability to operate in the presence of ground planes close to the sensor. QMatrix sensitivity is attributed more to the interaction of the electric fields between the transmitting (X) and receiving (Y) electrodes than to the surface area of these electrodes. For this reason, stray capacitance on the X or Y electrodes does not strongly reduce sensitivity.

Front panel dielectric material has a direct bearing on sensitivity. Plastic front panels are usually suitable up to about 1.2 mm, and glass up to about 2.5 mm (dependent upon the screen size and layout). The thicker the front panel, the lower the signal-to-noise ratio of the measured capacitive changes and hence the lower the resolution of the touchscreen. In general, glass front panels are near optimal because they conduct electric fields almost twice as easily as plastic panels.

NOTE Care should be taken using ultra-thin glass panels as retransmission effects can occur, which can significantly degrade performance.

4.0 SENSOR LAYOUT

The physical matrix can be configured to have one or more touch objects. These are configured using the appropriate touch objects (Multiple Touch Touchscreen and Key Array). It is not mandatory to have all the allowable touch objects present. The objects are disabled by default so only those that you wish to use need to be enabled.

4.1 Electrodes

The device supports various configurations of electrodes as summarized below:

- Touchscreen: 12 X × 12 Y maximum (subject to other configurations)
- Keys: Up to 8 keys in an X/Y grid (Key Array)

NOTE The specific electrode designs used in Microchip touchscreens are the subject of various patents and patent applications. Further information is available on request.

4.2 Touch Panel Layout

When designing the physical layout of the touch panel, the following rules must be obeyed:

- General layout rules:
  - Each touch object should be a regular rectangular shape in terms of the lines it uses.
  - Although each touch object must use a contiguous block of X or Y lines, there can be gaps between the blocks of X and Y lines used for the different touch objects
- Additional layout rules for Multiple Touch Touchscreen T100:
  - The Multiple Touch Touchscreen T100 object **must** start at X0, Y0.
  - The Multiple Touch Touchscreen T100 object cannot share an X or Y line with another touch object (for example, a Key Array T15).
  - For mutual capacitance measurements, the touchscreen must contain a minimum of 3 X lines. If Dual X Drive is enabled for use in the Noise Suppression T72 object, the minimum is increased to 4.

    The touchscreen must contain a minimum of 3 Y lines.
  - For self capacitance measurements, the touchscreen must contain an even number of X and Y lines with a minimum of 4; that is, 4, 6, 8,10 or 12 X and 4, 6, 8,10 or 12 Y lines
- Additional layout rules for Key Array T15:
  - The Key Array should occupy higher X and Y lines than those used by the Multiple Touch Touchscreen T100 object
  - The Key Array T15 object cannot share an X or Y line with the Multiple Touch Touchscreen T100 object.

4.3 Permitted Configurations

The permitted configurations are shown in Table 4-1.

TABLE 4-1: PERMITTED TOUCHSCREEN CONFIGURATIONS

Mutual Capacitance Sensing

Number of Y Lines	Number of X Lines											
	12	11	10	9	8	7	6	5	4	3	2	1
12	Y	Y	Y	Y	Y	Y	Y	Y	Y	X		
11	Y	Y	Y	Y	Y	Y	Y	Y	Y	X		
10	Y	Y	Y	Y	Y	Y	Y	Y	Y	X		
9	Y	Y	Y	Y	Y	Y	Y	Y	Y	X		
8	Y	Y	Y	Y	Y	Y	Y	Y	Y	X		
7	Y	Y	Y	Y	Y	Y	Y	Y	Y	X		
6	Y	Y	Y	Y	Y	Y	Y	Y	Y	X		
5	Y	Y	Y	Y	Y	Y	Y	Y	Y	X		
4	Y	Y	Y	Y	Y	Y	Y	Y	Y	X		
3	Y	Y	Y	Y	Y	Y	Y	Y	Y	X		
2												
1												

Self Capacitance Sensing

Number of Y Lines	Number of X Lines												
	12	11	10	9	8	7	6	5	4	3	2	1	
12	Y		Y		Y		Y		Y				
11													
10	Y		Y		Y		Y		Y				
9													
8	Y		Y		Y		Y		Y				
7													
6	Y		Y		Y		Y		Y				
5													
4	Y		Y		Y		Y		Y				
3													
2													
1													

Key: 🟩 Y Configuration supported 🟨 X Configuration supported, but only if dual X is not used ▨ Configuration not supported

4.4 Screen Size

Table 4-2 lists some typical screen size and electrode pitch combinations to achieve various aspect ratios.

TABLE 4-2: TYPICAL SCREEN SIZES

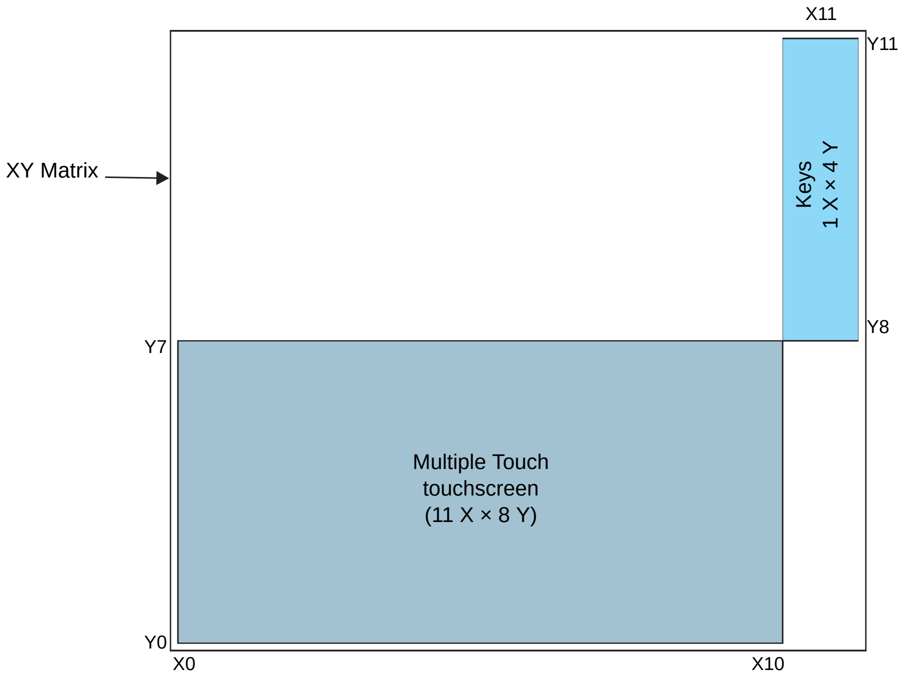
Aspect Ratio	Matrix Size	Node Count	Screen Diagonal (Inches)			
			4.5 mm Pitch	5 mm Pitch	5.5 mm Pitch	6 mm Pitch
16:10	X = 8, Y = 12	96	2.56	2.84	3.12	3.41
4:3	X = 9, Y = 12	108	2.66	2.95	3.25	3.54
1:1	X = 12, Y = 12	144	3.01	3.34	3.67	4.01

4.5 Key Array

For optimal performance in terms of cycle time overhead, it is recommended that the number of X (drive) lines used for the standard Key Array is kept to the minimum and designs should favor using Y lines where possible.

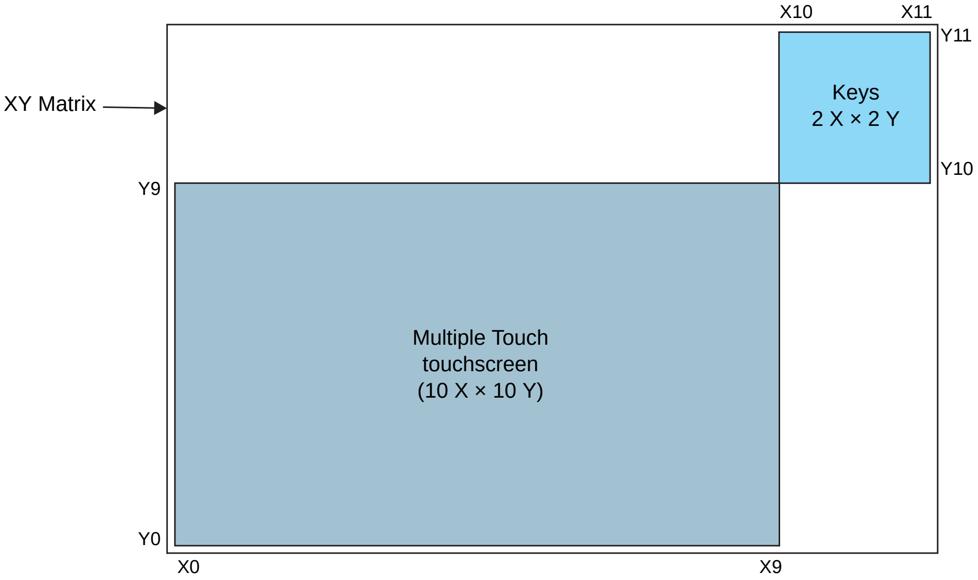
Figure 4-1 shows an example layout for a Touchscreen with a Key Array of 1 X × 4 Y lines. Note that in this case using 1 X × 4 Y lines for the Key Array would give better performance than using 4 X × 1 Y lines.

FIGURE 4-1: EXAMPLE LAYOUT – OPTIMAL CYCLE TIME



If, however, the intention is to preserve a larger touchscreen size and maintain an optimal aspect ratio, then using equal X and Y lines for the key array can be considered, as in Figure 4-2.

FIGURE 4-2: EXAMPLE LAYOUT – OPTIMAL ASPECT RATIO



5.0 POWER-UP / RESET REQUIREMENTS

5.1 Power-on Reset

There is an internal Power-on Reset (POR) in the device.

If an external reset is to be used the device must be held in $\overline{\text{RESET}}$ (active low) while the digital (Vdd) and digital I/O (VddIO) power supplies are powering up. The supplies must have reached their nominal values before the RESET signal is deasserted (that is, goes high). See Section 11.2 “Recommended Operating Conditions” for nominal values for the power supplies to the device.

It is recommended that customer designs include the capability for the host to control all the maXTouch power supplies and pull the $\overline{\text{RESET}}$ line low.

After power-up, the device typically takes 39 ms before it is ready to start communications.

NOTE Device initialization will not complete until after all the power supplies are present. If any power supply is not present, internal initialization stalls and the device will not communicate with the host.

If the $\overline{\text{RESET}}$ line is released before the Vdd supply has reached its nominal voltage, then some additional operations need to be carried out by the host. There are two options open to the host controller:

- Start the part in deep sleep mode and then send the command sequence to set the cycle time to wake the part and allow it to run normally. Note that in this case a calibration command is also needed.
- Send a RESET command.

The $\overline{\text{RESET}}$ pin can be used to reset the device whenever necessary. The $\overline{\text{RESET}}$ pin must be asserted low for at least 90 ns to cause a reset. After releasing the $\overline{\text{RESET}}$ pin the device typically takes 39 ms before it is ready to start communications. It is recommended to connect the $\overline{\text{RESET}}$ pin to a host controller to allow it to initiate a full hardware reset without requiring a power-down.

WARNING The device should be reset only by using the $\overline{\text{RESET}}$ line. If an attempt is made to reset by removing the power from the device without also sending the signal lines low, power will be drawn from the interface lines and the device will not reset correctly.

Make sure that any lines connected to the device are below or equal to Vdd during power-up. For example, if $\overline{\text{RESET}}$ is supplied from a different power domain to the VDDIO pin, make sure that it is held low when Vdd is off. If this is not done, the $\overline{\text{RESET}}$ signal could parasitically couple power via the $\overline{\text{RESET}}$ pin into the Vdd supply.

NOTE The voltage level on the $\overline{\text{RESET}}$ pin of the device must never exceed VddIO (digital supply voltage).

A software RESET command (using the Command Processor T6 object) can be used to reset the chip. A software reset typically takes 55 ms. After the chip has finished it asserts the $\overline{\text{CHG}}$ line to signal to the host that a message is available. The reset flag is set in the Message Processor object to indicate to the host that it has just completed a reset cycle. This bit can be used by the host to detect any unexpected brownout events. This allows the host to take any necessary corrective actions, such as reconfiguration.

NOTE The $\overline{\text{CHG}}$ line is briefly set as an input during power-up or reset. It is therefore particularly important that the line should be allowed to float high via the $\overline{\text{CHG}}$ line pull-up resistor during this period. It should not be driven by the host (see Section 11.5.3 “Reset Timings”).

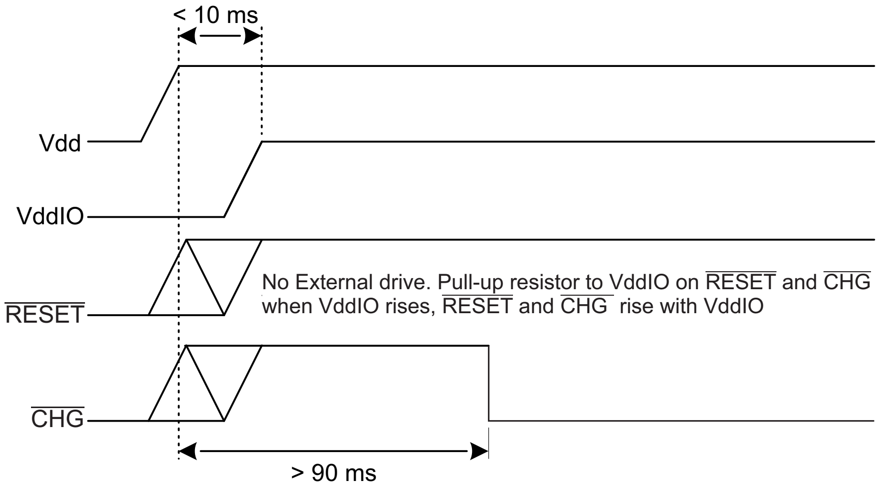
At power-on, the device performs a self-test routine (using the Self Test T25 object) to check for shorts that might cause damage to the device.

5.2 Power-up and Reset Sequence – VddIO Enabled after Vdd

The power-up sequence that can be used in applications where VddIO must be powered up after Vdd, is shown in Figure 5-1.

In this case the communication interface to the maXTouch device is not driven by the host system. The $\overline{\text{RESET}}$ and $\overline{\text{CHG}}$ pins are connected to VddIO using suitable pull-up resistors. Vdd is powered up, followed by VddIO, no more than 10 ms after Vdd. Due to the pull-up resistors, $\overline{\text{RESET}}$ and $\overline{\text{CHG}}$ will rise with VddIO. The internal POR system ensures reliable boot up of the device and the $\overline{\text{CHG}}$ line will go low approximately 39 ms after Vdd to notify the host that the device is ready to start communication.

FIGURE 5-1: POWER-UP SEQUENCE



5.3 Summary

The power-up and reset requirements for the maXTouch devices are summarized in Table 5-1.

TABLE 5-1: POWER-UP AND RESET REQUIREMENTS

Condition	External RESET	VddIO Delay (After Vdd)	Vdd Power-Up	Comments
1	Low at Power-up	0 ms	Before RESET is released	If Vdd bring-up is delayed, then additional actions will be required by the host (see Section 5.1 “Power-on Reset”
2	Not driven	<10 ms	Before VddIO	

6.0 DETAILED OPERATION

6.1 Touch Detection

The mXT144U allows for both mutual and self capacitance measurements, with the self capacitance measurements being used to augment the mutual capacitance measurements to produce reliable touch information.

When self capacitance measurements are enabled, touch classification is achieved using both mutual and self capacitance touch data. This has the advantage that both types of measurement systems can work together to detect touches under a wide variety of circumstances.

Mutual capacitance touch data is used wherever possible to classify touches as this has greater granularity than self capacitance measurements and provides positional information on touches.

Self capacitance measurements, on the other hand, allow for the detection of single touches in extreme cases, such as single thick glove touches, when touches can only be detected by self capacitance data and may be missed by mutual capacitance touch detection.

6.2 Operational Modes

The device operates in two modes: **Active** (touch detected) and **Idle** (no touches detected). Both modes operate as a series of burst cycles. Each cycle consists of a short burst (during which measurements are taken) followed by an inactive sleep period. The difference between these modes is the length of the cycles. Those in idle mode typically have longer sleep periods. The cycle length is configured using the IDLEACQINT and ACTVACQINT settings in the Power Configuration T7. In addition, an *Active to Idle Timeout* setting is provided.

6.3 Detection Integrator

The device features a touch detection integration mechanism. This acts to confirm a detection in a robust fashion. A counter is incremented each time a touch has exceeded its threshold and has remained above the threshold for the current acquisition. When this counter reaches a preset limit the sensor is finally declared to be touched. If, on any acquisition, the signal is not seen to exceed the threshold level, the counter is cleared and the process has to start from the beginning.

The detection integrator is configured using the appropriate touch objects (Multiple Touch Touchscreen T100, Key Array T15).

6.4 Sensor Acquisition

The charge time is set using the Acquisition Configuration T8 object.

A number of factors influence the acquisition time for a single drive line and the total acquisition time for the sensor as a whole must not exceed 250 ms. If this condition is not met, a SIGERR will be reported.

Care should be taken to configure all the objects that can affect the measurement timing, for example, Acquisition Configuration T8, CTE Configuration T46 and Self Capacitance Configuration T111, so that these limits are not exceeded.

6.5 Calibration

Calibration is the process by which a sensor chip assesses the background capacitance on each node. Nodes are only calibrated on reset and when:

- The node is enabled (that is, activated)

or

- The node is already enabled and one of the following applies:
  - The node is held in detect for longer than the Touch Automatic Calibration setting (TCHAUTOCAL in the Acquisition Configuration T8 object)
  - The signal delta on a node is at least the touch threshold (TCHTHR – TCHHYST) in the anti-touch direction, while it meets the criteria in the Touch Recovery Processes that results in a recalibration
  - The host issues a recalibrate command
  - Certain configuration settings are changed

A status message is generated on the start and completion of a calibration.

Note that the device performs a global calibration; that is, all the nodes are calibrated together.

6.6 Digital Filtering and Noise Suppression

The mXT144U supports on-chip filtering of the acquisition data received from the sensor. Specifically, the Noise Suppression T72 object provides an algorithm to suppress the effects of noise (for example, from a noisy charger plugged into the user's product). This algorithm can automatically adjust some of the acquisition parameters on-the-fly to filter the analog-to-digital conversions (ADCs) received from the sensor.

Additional noise suppression is provided by the Self Capacitance Noise Suppression T108 object. Similar in both design and configuration to the Noise Suppression T72 object, the Self Capacitance Noise Suppression T108 object is the noise suppression interface for self capacitance touch measurements.

Noise suppression is triggered when a noise source is detected.

- The host driver code can indicate when a noise source is present.
- The noise suppression is also triggered based on the noise levels detected using internal line measurements.The Noise Suppression T72 and Self Capacitance Noise Suppression T108 object selects the appropriate controls to suppress the noise present in the system.

6.7 Shieldless Support and Display Noise Suppression

The mXT144U can support shieldless sensor design even with a noisy LCD.

The Optimal Integration feature is not filtering as such, but enables the user to use a shorter integration window. The integration window optimizes the amount of charge collected against the amount of noise collected, to ensure an optimal SNR. This feature also benefits the system in the presence of an external noise source. This feature is configured using the Shieldless T56 object.

Display noise suppression allows the device to overcome display noise simultaneously with external noise. This feature is based on filtering provided by the Lens Bending T65 object (see Section 6.10 “Lens Bending”).

6.8 Retransmission Compensation

The device can limit the undesirable effects on the mutual capacitance touch signals caused by poor device coupling to ground, such as poor sensitivity and touch break-up. This is achieved using the Retransmission Compensation T80 object. This object can be configured to allow the touchscreen to compensate for signal degradation due to these undesirable effects. If self capacitance measurements are also scheduled, the Retransmission Compensation T80 object will use the resultant data to enhance the compensation process.

The Retransmission Compensation T80 object is also capable of compensating for water presence on the sensor if self capacitance measurements are scheduled. In this case, both mutual capacitance and self capacitance measurements are used to detect moisture and then, once moisture is detected, self capacitance measurements are used to detect single touches in the presence of moisture.

6.9 Grip Suppression

The device has grip suppression functionality to suppress false detections from a user's grip.

Mutual capacitance grip suppression works by specifying a boundary around a touchscreen, within which touches can be suppressed whilst still allowing touches in the center of the touchscreen. This ensures that an accidental hand touch on the edge is suppressed while still allowing a “real” (finger) touch towards the center of the screen. Mutual capacitance grip suppression is configured using the Grip Suppression T40 object.

6.10 Lens Bending

The device supports algorithms to eliminate disturbances from the measured signal.

When the sensor suffers from the screen deformation (lens bending) the signal values acquired by normal procedure are corrupted by the disturbance component (bend). The amount of bend depends on:

- The mechanical and electrical characteristics of the sensor
- The amount and location of the force applied by the user touch to the sensor

The Lens Bending T65 object measures the bend component and compensates for any distortion caused by the bend. As the bend component is primarily influenced by the user touch force, it can be used as a secondary source to identify the presence of a touch. The additional benefit of the Lens Bending T65 object is that it will eliminate LCD noise as well.

6.11 Glove Detection

The device has glove detection algorithms that process the measurement data received from the touchscreen classifying touches as potential gloved touches.

The Glove Detection T78 object is used to detect glove touches. In Normal Mode the Glove Detection T78 object applies vigorous glove classification to small signal touches to minimize the effect of unintentional hovering finger reporting. Once a gloved touch is found, the Glove Detection T78 object enters Glove Confidence Mode. In this mode the device expects the user to be wearing gloves so the classification process is much less stringent.

6.12 Unintentional Touch Suppression

The Touch Suppression T42 object provides a mechanism to suppress false detections from unintentional touches from a large body area, such as from a face, ear or palm. The Touch Suppression T42 object also provides Maximum Touch Suppression to suppress all touches if more than a specified number of touches has been detected. There is one instance of the Touch Suppression T42 object for each Multiple Touch Touchscreen T100 object present on the device.

6.13 Adjacent Key Suppression Technology

Adjacent Key Suppression (AKS) technology is a patented method used to detect which touch object (Multiple Touch Touchscreen T100 or Key Array T15) is touched, and to suppress touches on the other touch objects, when touch objects are located close together.

The device has two levels of AKS:

- The first level works between the touch objects (Multiple Touch Touchscreen T100 and Key Array T15). The touch objects are assigned to AKS groups. If a touch occurs within one of the touch objects in a group, then touches within other objects inside that group are suppressed. For example, if a touchscreen and a Key Array are placed in the same AKS group, then a touch in the touchscreen will suppress touches in the Key Array, and vice versa. Objects can be in more than one AKS group.
- The second level of AKS is internal AKS within an individual Key Array object. If internal AKS is enabled, then when one key is touched, touches on all the other keys within the Key Array are suppressed. Note that internal AKS is not present on other types of touch objects.

7.0 I^2C COMMUNICATIONS

Communication with the device is carried out over the I^2C interface.

The I^2C interface is used in conjunction with the $\overline{\text{CHG}}$ line. The $\overline{\text{CHG}}$ line going active signifies that a new data packet is available. This provides an interrupt-style interface and allows the device to present data packets when internal changes have occurred. See Section 7.6 “CHG Line” for more information.

7.1 I^2C Address

The device supports one I^2C device address – 0x4A.

The I^2C address is shifted left to form the SLA+W or SLA+R address when transmitted over the I^2C interface, as shown in Table 7-1.

TABLE 7-1: FORMAT OF AN I^2C ADDRESS

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Address: 0x4A							Read/write

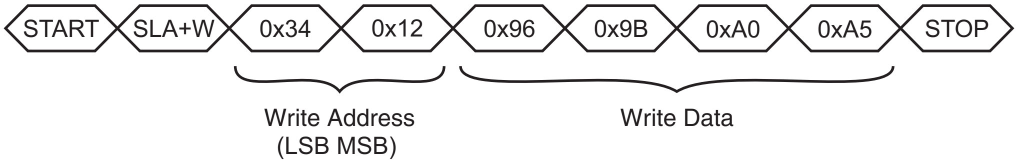
7.2 Writing To the Device

A WRITE cycle to the device consists of a START condition followed by the I^2C address of the device (SLA+W). The next two bytes are the address of the location into which the writing starts. The first byte is the Least Significant Byte (LSByte) of the address, and the second byte is the Most Significant Byte (MSByte). This address is then stored as the address pointer.

Subsequent bytes in a multi-byte transfer form the actual data. These are written to the location of the address pointer, location of the address pointer + 1, location of the address pointer + 2, and so on. The address pointer returns to its starting value when the WRITE cycle STOP condition is detected.

Figure 7-1 shows an example of writing four bytes of data to contiguous addresses starting at 0x1234.

FIGURE 7-1: EXAMPLE OF A FOUR-BYTE WRITE STARTING AT ADDRESS 0X1234

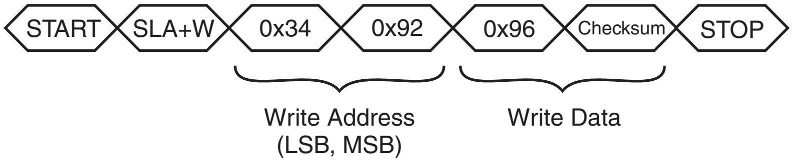


7.3 I^2C Writes in Checksum Mode

In I^2C checksum mode an 8-bit CRC is added to all I^2C writes. The CRC is sent at the end of the data write as the last byte before the STOP condition. All the bytes sent are included in the CRC, including the two address bytes. Any command or data sent to the device is processed even if the CRC fails.

To indicate that a checksum is to be sent in the write, the most significant bit of the MSByte of the address is set to 1. For example, the I^2C command shown in Figure 7-2 writes a value of 150 (0x96) to address 0x1234 with a checksum. The address is changed to 0x**9**234 to indicate checksum mode.

FIGURE 7-2: EXAMPLE OF A WRITE TO ADDRESS 0X1234 WITH A CHECKSUM



7.4 Reading From the Device

Two I^{2}C bus activities must take place to read from the device. The first activity is an I^{2}C write to set the address pointer (LSByte then MSByte). The second activity is the actual I^{2}C read to receive the data. The address pointer returns to its starting value when the read cycle NACK is detected.

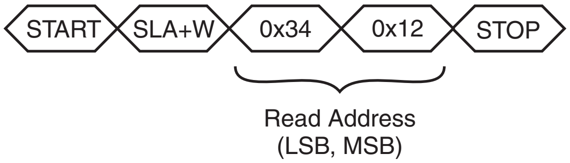
It is not necessary to set the address pointer before every read. The address pointer is updated automatically after every read operation. The address pointer will be correct if the reads occur in order. In particular, when reading multiple messages from the Message Processor T5 object, the address pointer is automatically reset to allow continuous reads (see Section 7.5 “Reading Status Messages with DMA”).

The WRITE and READ cycles consist of a START condition followed by the I^{2}C address of the device (SLA+W or SLA+R respectively). Note that in this mode, calculating a checksum of the data packets is not supported.

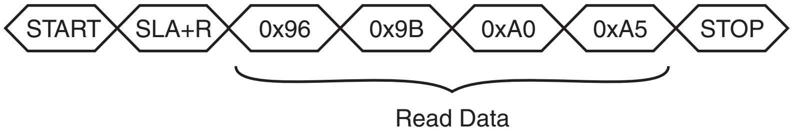
Figure 7-3 shows the I^{2}C commands to read four bytes starting at address 0x1234.

FIGURE 7-3: EXAMPLE OF A FOUR-BYTE READ STARTING AT ADDRESS 0X1234

Set Address Pointer



Read Data



7.5 Reading Status Messages with DMA

The device facilitates the easy reading of multiple messages using a single continuous read operation. This allows the host hardware to use a direct memory access (DMA) controller for the fast reading of messages, as follows:

1. The host uses a write operation to set the address pointer to the start of the Message Count T44 object, if necessary. Note that the STOP condition at the end of the read resets the address pointer to its initial location, so it may already be pointing at the Message Count T44 object following a previous message read. If a checksum is required on each message, the most significant bit of the MSByte of the read address must be set to 1.
2. The host starts the read operation of the message by sending a START condition.
3. The host reads the Message Count T44 object (one byte) to retrieve a count of the pending messages.
4. The host calculates the number of bytes to read by multiplying the message count by the size of the Message Processor T5 object. Note that the host should have already read the size of the Message Processor T5 object in its initialization code.
5. Note that the size of the Message Processor T5 object as recorded in the Object Table includes a checksum byte. If a checksum has not been requested, one byte should be deducted from the size of the object.
   That is: number of bytes = count × (size – 1).
6. The host reads the calculated number of message bytes. It is important that the host does *not* send a STOP condition during the message reads, as this will terminate the continuous read operation and reset the address pointer. No START and STOP conditions must be sent between the messages.
7. The host sends a STOP condition at the end of the read operation after the last message has been read. The NACK condition immediately before the STOP condition resets the address pointer to the start of the Message Count T44 object.

Figure 7-4 shows an example of using a continuous read operation to read three messages from the device without a checksum. Figure 7-5 shows the same example with a checksum.

FIGURE 7-4: CONTINUOUS MESSAGE READ EXAMPLE – NO CHECKSUM

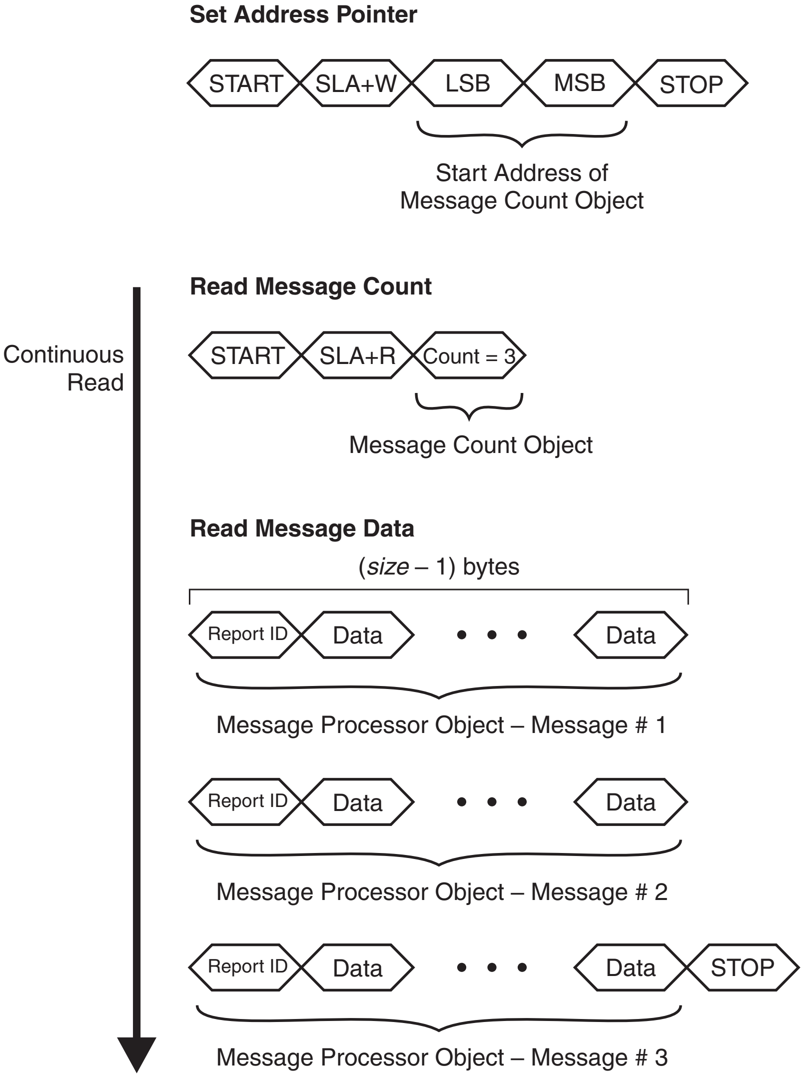
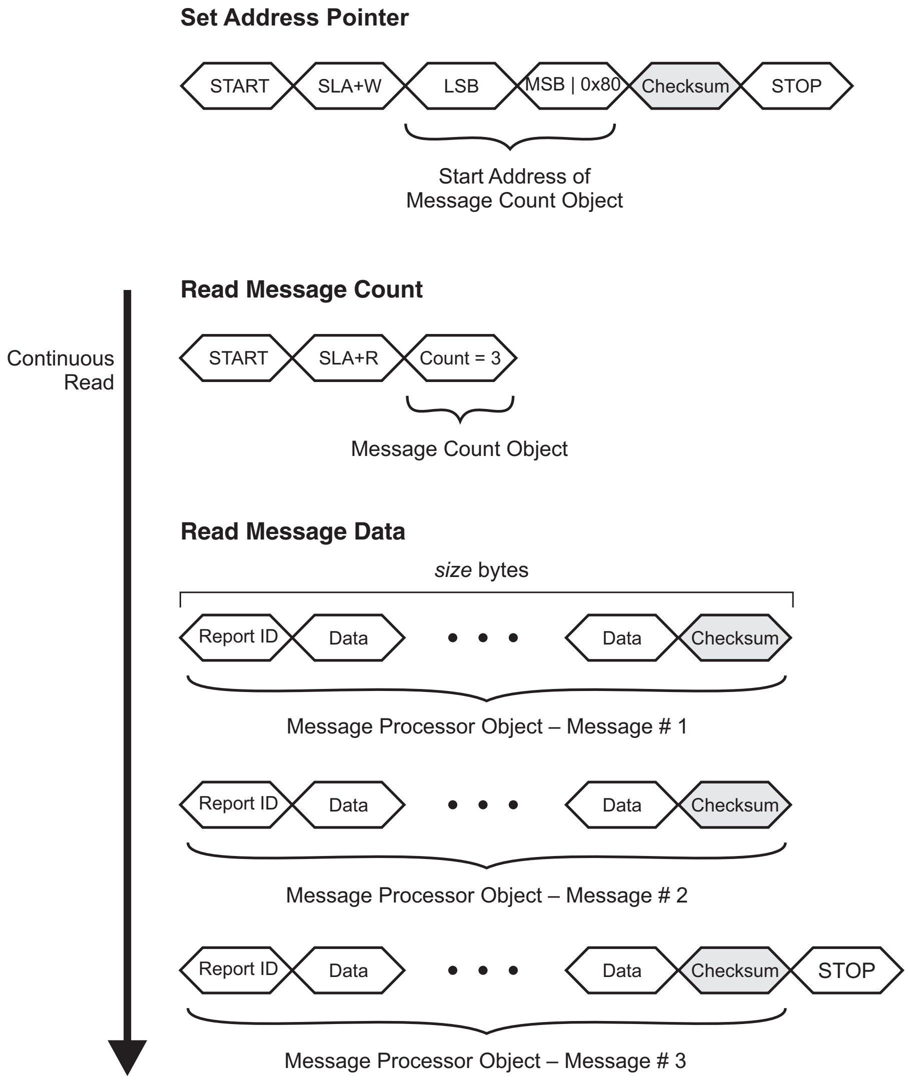


FIGURE 7-5: CONTINUOUS MESSAGE READ EXAMPLE – I^{2}C CHECKSUM MODE



There are no checksums added on any other I^{2}C reads. An 8-bit CRC can be added, however, to all I^{2}C writes, as described in Section 7.3 “I^{2}C Writes in Checksum Mode”.

An alternative method of reading messages using the $\overline{\text{CHG}}$ line is given in Section 7.6 “CHG Line”.

7.6 $\overline{\text{CHG}}$ Line

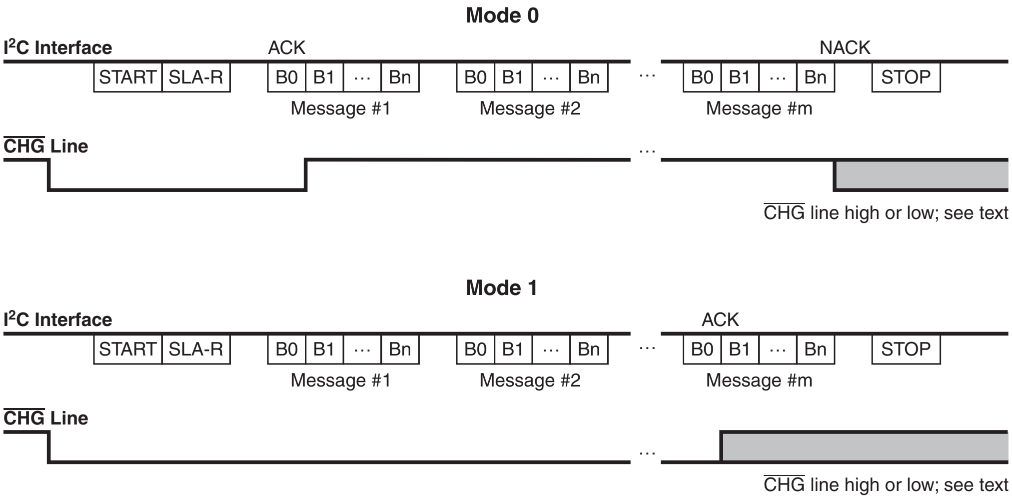
The $\overline{\text{CHG}}$ line is an active-low, open-drain output that is used to alert the host that a new message is available in the Message Processor T5 object. This provides the host with an interrupt-style interface with the potential for fast response times. It reduces the need for wasteful I^{2}C communications.

The $\overline{\text{CHG}}$ line should always be configured as an input on the host during normal usage. This is particularly important after power-up or reset (see Section 5.0 “Power-up / Reset Requirements”).

A pull-up resistor is required to VddIO (see Section 2.0 “Schematic”).

The $\overline{\text{CHG}}$ line operates in two modes when it is used with I^{2}C communications, as defined by the Communications Configuration T18 object.

FIGURE 7-6: $\overline{\text{CHG}}$ LINE MODES FOR I^{2}C-COMPATIBLE TRANSFERS



In Mode 0 (edge-triggered operation):

1. The $\overline{\text{CHG}}$ line goes low to indicate that a message is present.
2. The $\overline{\text{CHG}}$ line goes high when the first byte of the first message (that is, its report ID) has been sent and acknowledged (ACK sent) and the next byte has been prepared in the buffer.
3. The STOP condition at the end of an I^{2}C transfer causes the $\overline{\text{CHG}}$ line to stay high if there are no more messages. Otherwise the $\overline{\text{CHG}}$ line goes low to indicate a further message.

Note that Mode 0 also allows the host to continually read messages by simply continuing to read bytes back without issuing a STOP condition. Message reading should end when a report ID of 255 (“invalid message”) is received. Alternatively the host ends the transfer by sending a NACK after receiving the last byte of a message, followed by a STOP condition. If there is another message present, the $\overline{\text{CHG}}$ line goes low again, as in step 1. In this mode the state of the $\overline{\text{CHG}}$ line does not need to be checked during the I^{2}C read.

In Mode 1 (level-triggered operation):

1. The $\overline{\text{CHG}}$ line goes low to indicate that a message is present.
2. The $\overline{\text{CHG}}$ line remains low while there are further messages to be sent after the current message.
3. The $\overline{\text{CHG}}$ line goes high again only once the first byte of the last message (that is, its report ID) has been sent and acknowledged (ACK sent) and the next byte has been prepared in the output buffer.

Mode 1 allows the host to continually read the messages until the $\overline{\text{CHG}}$ line goes high, and the state of the $\overline{\text{CHG}}$ line determines whether or not the host should continue receiving messages from the device.

> **NOTE** The state of the $\overline{\text{CHG}}$ line should be checked only between messages and not between the bytes of a message. The precise point at which the $\overline{\text{CHG}}$ line changes state cannot be predicted and so the state of the $\overline{\text{CHG}}$ line cannot be guaranteed between bytes.

The Communications Configuration T18 object can be used to configure the behavior of the $\overline{\text{CHG}}$ line. In addition to the $\overline{\text{CHG}}$ line operation modes described above, this object allows direct control over the state of the $\overline{\text{CHG}}$ line.

7.7 SDA and SCL

The I^{2}C bus transmits data and clock with SDA and SCL, respectively. These are open-drain. The device can only drive these lines low or leave them open. The termination resistors (Rp) pull the line up to VddIO if no I^{2}C device is pulling it down.

The termination resistors should be chosen so that the rise times on SDA and SCL meet the I^{2}C specifications for the interface speed being used, bearing in mind other loads on the bus. For best latency performance, it is recommended that no other devices share the I^{2}C bus with the maXTouch controller.

7.8 Clock Stretching

The device supports clock stretching in accordance with the I^2C specification. It may also instigate a clock stretch if a communications event happens during a period when the device is busy internally. The maximum clock stretch is approximately 10 – 15 ms.

8.0 PCB DESIGN CONSIDERATIONS

8.1 Introduction

The following sections give the design considerations that should be adhered to when designing a PCB layout for use with the mXT144U. Of these, power supply and ground tracking considerations are the most critical.

By observing the following design rules, and with careful preparation for the PCB layout exercise, designers will be assured of a far better chance of success and a correctly functioning product.

8.2 Printed Circuit Board

Microchip recommends the use of a four-layer printed circuit board for mXT144U applications. This, together with careful layout, will ensure that the board meets relevant EMC requirements for both noise radiation and susceptibility, as laid down by the various national and international standards agencies.

8.2.1 PCB CLEANLINESS

Modern no-clean-flux is generally compatible with capacitive sensing circuits.

CAUTION!	If a PCB is reworked to correct soldering faults relating to any device, or to any associated traces or components, be sure that you fully understand the nature of the flux used during the rework process. Leakage currents from hygroscopic ionic residues can stop capacitive sensors from functioning. If you have any doubts, a thorough cleaning after rework may be the only safe option.

8.3 Power Supply

8.3.1 SUPPLY QUALITY

While the device has good Power Supply Rejection Ratio properties, poorly regulated and/or noisy power supplies can significantly reduce performance.

8.3.2 SUPPLY RAILS AND GROUND TRACKING

Power supply and clock distribution are the most critical parts of any board layout. Because of this, it is advisable that these be completed before any other tracking is undertaken. After these, supply decoupling, and analog and high speed digital signals should be addressed. Track widths for all signals, especially power rails should be kept as wide as possible in order to reduce inductance.

The Power and Ground planes themselves can form a useful capacitor. Flood filling for either or both of these supply rails, therefore, should be used where possible. It is important to ensure that there are no floating copper areas remaining on the board: all such areas should be connected to the ground plane. The flood filling should be done on the outside layers of the board.

8.3.3 POWER SUPPLY DECOUPLING

Decoupling capacitors should be fitted as specified in Section 2.2 “Schematic Notes”.

The decoupling capacitors must be placed as close as possible to the pin being decoupled. The traces from these capacitors to the respective device pins should be wide and take a straight route. They should be routed over a ground plane as much as possible. The capacitor ground pins should also be connected directly to a ground plane.

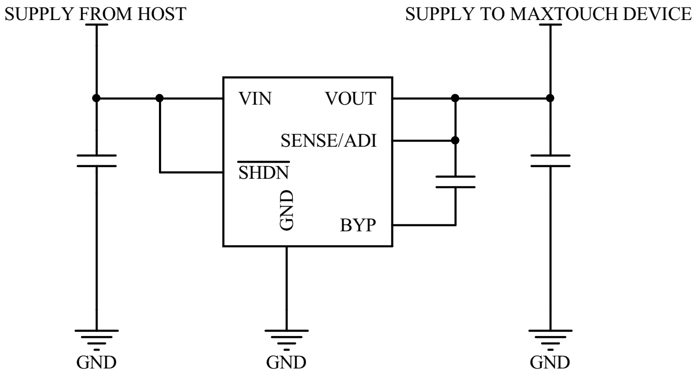
Surface mounting capacitors are preferred over wire-leaded types due to their lower ESR and ESL. It is often possible to fit these decoupling capacitors underneath and on the opposite side of the PCB to the digital ICs. This will provide the shortest tracking, and most effective decoupling possible.

8.4 Voltage Regulators

Each supply rail requires a Low Drop-Out (LDO) voltage regulator, although an LDO can be shared where supply rails share the same voltage level.

Figure 8-1 shows an example circuit for an LDO.

FIGURE 8-1: EXAMPLE LDO CIRCUIT



An LDO regulator should be chosen that provides adequate output capability, low noise, good load regulation and step response. The voltage regulators listed in Table 8-1 have been tested and found to work well with maXTouch devices. If it is desired to use an alternative LDO, however, certain performance criteria should be verified before using the device. These are:

- Stable with high value multi-layer ceramic capacitors on the output
- Low output noise – less than 100 µV RMS over the range 10 Hz to 1 MHz
- Good load transient response – this should be less than 35 mV peak when a load step change of 100 mA is applied at the device output terminal
- No-load stable – Some LDOs become unstable if the output current falls below a certain minimum. If this is the case, then this minimum must be lower than the minimum current consumed by the mXT144U (for example, in deep sleep).

TABLE 8-1: SUITABLE LDO REGULATORS

Manufacturer	Device	Current Rating (mA)
Microchip Technology Inc.	MCP1824	300
Microchip Technology Inc.	MCP1824S	300
Microchip Technology Inc.	MAQ5300	300
Microchip Technology Inc.	MCP1725	500
Microchip Technology Inc.	MIC5323	300
Analog Devices	ADP122/ADP123	300
Diodes Inc.	AP2125	300
Diodes Inc.	AP7335	300
Linear Technology	LT1763CS8-3.3	500
NXP	LD6836	300
Texas Instruments	LP3981	300

Note: Some manufacturers claim that minimal or no capacitance is required for correct regulator operation. However, in all cases, a minimum of a 1.0 µF ceramic, low ESR capacitor at the input and output of these devices should be used. The manufacturer’s datasheets should always be referred to when selecting capacitors for these devices and the typical recommended values, types and dielectrics adhered to.

8.4.1 SINGLE SUPPLY OPERATION

When designing a PCB for an application using a single LDO, extra care should be taken to ensure short, low inductance traces between the supply and the touch controller supply input pins. Ideally, tracking for the individual supplies should be arranged in a star configuration, with the LDO at the junction of the star. This will ensure that supply current variations or noise in one supply rail will have minimum effect on the other supplies. In applications where a ground plane is not practical, this same star layout should also apply to the power supply ground returns.

Only regulators with a 300 mA or greater rating can be used in a single-supply design.

Refer to the following application note for more information on routing with a single LDO:

- Application Note: MXTAN0208 – *Design Guide for PCB Layouts for maXTouch Touch Controllers*

8.5 Analog I/O

In general, tracking for the analog I/O signals from the device should be kept as short as possible. These normally go to a connector which interfaces directly to the touchscreen.

Ensure that adequate ground-planes are used. An analog ground plane should be used in addition to a digital one. Care should be taken to ensure that both ground planes are kept separate and are connected together only at the point of entry for the power to the PCB. This is usually at the input connector.

8.6 Component Placement and Tracking

It is important to orient all devices so that the tracking for important signals (such as power and clocks) are kept as short as possible.

8.6.1 DIGITAL SIGNALS

In general, when tracking digital signals, it is advisable to avoid sharp directional changes on sensitive signal tracks (such as analog I/O) and any clock or crystal tracking.

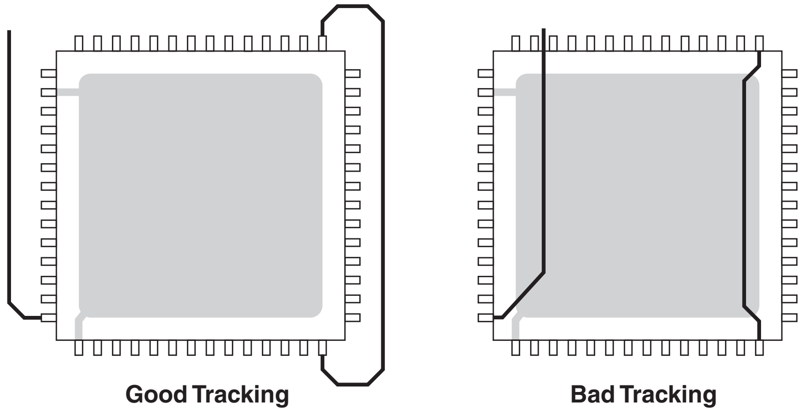
A good ground return path for all signals should be provided, where possible, to ensure that there are no discontinuities.

8.6.2 QFN PACKAGE RESTRICTIONS

The central pad on the underside of the QFN device should be connected to ground. Do not run any tracks underneath the body of the device, only ground. Figure 8-2 shows examples of good and bad tracking.

FIGURE 8-2: EXAMPLES OF GOOD AND BAD TRACKING

Note: The number of pins and their functions is shown for example purposes only and may not reflect the actual number or function on the device.



8.7 EMC and Other Observations

The following recommendations are not mandatory, but may help in situations where particularly difficult EMC or other problems are present:

- Try to keep as many signals as possible on the inside layers of the board. If suitable ground flood fills are used on the top and bottom layers, these will provide a good level of screening for noisy signals, both into and out of the PCB.

- Ensure that the on-board regulators have sufficient tracking around and underneath the devices to act as a heatsink. This heatsink will normally be connected to the 0 V or ground supply pin. Increasing the width of the copper tracking to any of the device pins will aid in removing heat. There should be no solder mask over the copper track underneath the body of the regulators.
- Ensure that the decoupling capacitors, especially high capacity ceramic type, have the requisite low ESR, ESL and good stability/temperature properties. Refer to the regulator manufacturer's datasheet for more information.

9.0 GETTING STARTED WITH MXT144U

9.1 Establishing Contact

9.1.1 COMMUNICATION WITH THE HOST

The host can use the following interface to communicate with the device:

- I^{2}C interface (see Section 7.0 “I2C Communications”)

9.1.2 POWER-UP SEQUENCE

On power-up, the $\overline{\text{CHG}}$ line goes low to indicate that there is new data to be read from the device. If the $\overline{\text{CHG}}$ line does not go low, there is a problem with the device.

Once the $\overline{\text{CHG}}$ line goes low, the host should attempt to read the first 7 bytes of memory from location 0x00 to establish that the device is present and running following power-up.

A checksum check is performed on the configuration settings held in the non-volatile memory. If the checksum does not match a stored copy of the last checksum, then this indicates that the settings have become corrupted. This is signaled to the host by setting the configuration error bit in the message data for the Command Processor T6 object.

9.2 Using the Object Protocol

The device has an object-based protocol that is used to communicate with the device. Typical communication includes configuring the device, sending commands to the device, and receiving messages from the device.

The host must perform the following initialization so that it can communicate with the device:

1. Read the start positions of all the objects in the device from the Object Table and build up a list of these addresses.
2. Use the Object Table to calculate the report IDs so that messages from the device can be correctly interpreted.

9.2.1 CLASSES OF OBJECTS

The mXT144U contains the following classes of objects:

- **Debug objects** – provide a raw data output method for development and testing.
- **General objects** – required for global configuration, transmitting messages and receiving commands.
- **Touch objects** – operate on measured signals from the touch sensor and report touch data.
- **Signal processing objects** – process data from other objects (typically signal filtering operations).
- **Support objects** – provide additional functionality on the device.

9.2.2 OBJECT INSTANCES

TABLE 9-1: OBJECTS ON THE MXT144U

Object	Description	Number of Instances	Usage
Debug Objects			
Diagnostic Debug T37	Allows access to diagnostic debug data to aid development.	1	Debug commands only. No configuration/tuning necessary. Not for use in production.
General Objects			
Message Processor T5	Handles the transmission of messages. This object holds a message in its memory space for the host to read.	1	No configuration necessary.
Command Processor T6	Performs a command when written to. Commands include reset, calibrate and backup settings.	1	No configuration necessary.

TABLE 9-1: OBJECTS ON THE MXT144U (CONTINUED)

Object	Description	Number of Instances	Usage
Power Configuration T7	Controls the sleep mode of the device. Power consumption can be lowered by controlling the acquisition frequency and the sleep time between acquisitions.	1	Must be configured before use.
Acquisition Configuration T8	Controls how the device takes each capacitive measurement.	1	Must be configured before use.
Touch Objects			
Key Array T15	Creates a rectangular array of keys. A Key Array T15 object reports simple on/off touch information.	1	Enable and configure as required.
Multiple Touch Touchscreen T100	Creates a Touchscreen that supports the tracking of more than one touch.	1	Enable and configure as required.
Signal Processing Objects			
One-touch Gesture Processor T24	Operates on the data from a Touchscreen object. A One-touch Gesture Processor T24 converts touches into one-touch finger gestures (for example, taps, double taps and drags).	1	Enable and configure as required.
Two-touch Gesture Processor T27	Operates on the data from a One-touch Gesture Processor T24 object. A Two-touch Gesture Processor T27 converts touches into two-touch finger gestures (for example, pinches, stretches and rotates).	1	Enable and configure as required.
Grip Suppression T40	Suppresses false detections caused, for example, by the user gripping the edge of the touchscreen.	1	Enable and configure as required.
Touch Suppression T42	Suppresses false detections caused by unintentional large touches by the user.	1	Enable and configure as required.
Shieldless T56	Allows a sensor to use true single-layer co-planar construction.	1	Enable and configure as required.
Lens Bending T65	Compensates for lens deformation (lens bending) by attempting to eliminate the disturbance signal from the reported deltas.	3	Enable and configure as required.
Noise Suppression T72	Performs various noise reduction techniques during touchscreen signal acquisition.	1	Enable and configure as required.
Glove Detection T78	Allows for the reporting of glove touches.	1	Enable and configure as required.
Retransmission Compensation T80	Limits the negative effects on touch signals caused by poor device coupling to ground.	1	Enable and configure as required.
Touch Sequence Processor T93	Captures a sequence of touch and release locations to allow double taps to be detected.	1	Enable and configure as required.
Self Capacitance Noise Suppression T108	Suppresses the effects of external noise within the context of self capacitance touch measurements.	1	Enable and configure as required.
Symbol Gesture Processor T115	Detects arbitrary shaped gestures as a series of ordinal strokes. These are typically symbols drawn by the user for interpretation by the host as wake-up gestures or other application triggers.	1	Enable and configure as required.

TABLE 9-1: OBJECTS ON THE MXT144U (CONTINUED)

Object	Description	Number of Instances	Usage
Sensor Correction T121	Allows adjustments to be made to mutual measurements from an associated touchscreen sensor.	1	Enable and configure as required.
Support Objects			
Communications Configuration T18	Configures additional communications behavior for the device.	1	Check and configure as necessary.
Self Test T25	Configures and performs self-test routines to find faults on a touch sensor.	1	Configure as required for pin test commands.
User Data T38	Provides a data storage area for user data.	1	Configure as required.
Message Count T44	Provides a count of pending messages.	1	Read-only object.
CTE Configuration T46	Controls the capacitive touch engine for the device.	1	Must be configured.
Timer T61	Provides control of a timer.	6	Enable and configure as required.
Serial Data Command T68	Provides an interface for the host driver to deliver various data sets to the device.	1	Enable and configure as required.
Dynamic Configuration Controller T70	Allows rules to be defined that respond to system events.	20	Enable and configure as required.
Dynamic Configuration Container T71	Allows the storage of user configuration on the device that can be selected at runtime based on rules defined in the Dynamic Configuration Controller T70 object.	1	Configure if Dynamic Configuration Controller T70 is in use.
Auxiliary Touch Configuration T104	Allows the setting of self capacitance gain and thresholds for a particular measurement to generate auxiliary touch data for use by other objects.	1	Enable and configure if using self capacitance measurements
Self Capacitance Global Configuration T109	Provides configuration for a self capacitance measurements employed on the device.	1	Check and configure as required (if using self capacitance measurements).
Self Capacitance Tuning Parameters T110	Provides configuration space for a generic set of settings for self capacitance measurements.	4	Use under the guidance of Microchip field engineers only.
Self Capacitance Configuration T111	Provides configuration for self capacitance measurements employed on the device.	2	Check and configure as required (if using self capacitance measurements).
Self Capacitance Measurement Configuration T113	Configures self capacitance measurements to generate data for use by other objects.	1	Enable and configure as required.
Symbol Gesture Configuration T116	Stores configuration data that defines the symbols to be detected by the Symbol Gesture Processor T115 object.	1	Configure if Symbol Gesture Processor T115 is in use.
Low Power Idle Configuration T126	Configures the overall behavior of the low power self capacitance features.	1	Enable and configure as required.

9.2.3 CONFIGURING AND TUNING THE DEVICE

The objects are designed such that a default value of zero in their fields is a “safe” value that typically disables functionality. The objects must be configured before use and the settings written to the non-volatile memory using the Command Processor T6 object.

Perform the following actions for each object:

1. Enable the object, if the object requires it.
2. Configure the fields in the object, as required.
3. Enable reporting, if the object supports messages, to receive messages from the object.

9.3 Writing to the Device

The following mechanisms can be used to write to the device:

- Using an I^2C write operation (see Section 7.2 “Writing To the Device”).

Communication with the device is achieved by writing to the appropriate object:

- To send a command to the device, an appropriate command is written to the Command Processor T6 object.
- To configure the device, a configuration parameter is written to the appropriate object. For example, writing to the Power Configuration T7 configures the power consumption for the device and writing to the touchscreen Multiple Touch Touchscreen T100 object sets up the touchscreen. Some objects are optional and need to be enabled before use.

IMPORTANT! When the host issues any command within an object that results in a flash write to the device Non-Volatile Memory (NVM), that object should have its CTRL RPTEN bit set to 1, if it has one. This ensures that a message from the object writing to the NVM is generated at the completion of the process and an assertion of the $\overline{\text{CHG}}$ line is executed.

The host must also ensure that the assertion of the $\overline{\text{CHG}}$ line refers to the expected object report ID before asserting the $\overline{\text{RESET}}$ line to perform a reset. Failure to follow this guidance may result in a corruption of device configuration area and the generation of a CFGERR.

9.4 Reading from the Device

Status information is stored in the Message Processor T5 object. This object can be read to receive any status information from the device. The following mechanisms provide an interrupt-style interface for reading messages in the Message Processor T5 object:

- The $\overline{\text{CHG}}$ line is asserted whenever a new message is available in the Message Processor T5 object (see Section 7.6 “CHG Line”). See Section 7.4 “Reading From the Device” for information on the format of the I^2C read operation.

Note that the host should always wait to be notified of messages. The host should not poll the device for messages.

10.0 DEBUGGING AND TUNING

10.1 SPI Debug Interface

The SPI Debug Interface is used for tuning and debugging when running the system and allows the development engineer to use Microchip maXTouch Studio to read the real-time raw data. This uses the low-level debug port, accessed via the SPI interface.

The SPI Debug Interface consists of the $\overline{\text{DBG\_SS}}$, DBG_CLK, and DBG_DATA lines. It is recommended that these pins are routed to test points on all designs such that they can be connected to external hardware during system development. These lines should not be connected to power or GND. See Section 2.2.7 “SPI Debug Interface” for more details.

The SPI Debug Interface is enabled by the Command Processor T6 object and by default will be off.

NOTE The touch controller will take care of the pin configuration. When the $\overline{\text{DBG\_SS}}$, DBG_CLK, and DBG_DATA lines are in use for debugging, any alternative function for the pins cannot be used.

10.2 Object-based Protocol

The device provides a mechanism for obtaining debug data for development and testing purposes by reading data from the Diagnostic Debug T37 object.

NOTE The Diagnostic Debug T37 object is of most use for simple tuning purposes. When debugging a design, it is preferable to use the SPI Debug Interface, as this will have a much higher bandwidth and can provide real-time data.

10.3 Self Test

There is a Self Test T25 object that runs self-test routines in the device to find hardware faults on the sense lines and the electrodes. This object also performs an initial pin fault test on power-up to ensure that there is no X-to-Y short before the high-voltage supply is enabled inside the chip. A high-voltage short on the sense lines would break the device.

11.0 SPECIFICATIONS

11.1 Absolute Maximum Specifications

Vdd	3.6 V
VddIO	3.6 V
Voltage forced onto any pin	–0.3 V to (Vdd or VddIO) + 0.3 V
Configuration parameters maximum writes	10,000
Maximum junction temperature	125°C

CAUTION! Stresses beyond those listed under *Absolute Maximum Specifications* may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum specification conditions for extended periods may affect device reliability.

11.2 Recommended Operating Conditions

Operating temperature	–40°C to +85°C
Storage temperature	–60°C to +150°C
Vdd	3.3 V
VddIO	1.8 V to 3.3 V
Temperature slew rate	10°C/min

11.2.1 DC CHARACTERISTICS

11.2.1.1 Digital Voltage Supply – Vdd, VddIO

Parameter	Min	Typ	Max	Units	Notes
VddIO					
Operating limits	1.71	3.3	3.6	V	I^2C
Supply Rise Rate	–	–	0.036	V/µs	For example, for a 3.3 V rail, the voltage must not rise in less than 92 µs
Vdd					
Operating limits	2.7	3.3	3.6	V	
Supply Rise Rate	–	–	0.036	V/µs	For example, for a 3.3 V rail, the voltage must not rise in less than 92 µs
Supply Fall Rate	–	–	0.05	V/µs	For example, for a 3.3 V rail, the voltage must not fall in less than 66 µs

11.2.2 POWER SUPPLY RIPPLE AND NOISE

Parameter	Min	Typ	Max	Units	Notes
Vdd	–	–	±50	mV	Across frequency range 1 Hz to 1 MHz

11.3 Test Configuration

The values listed below were used in the reference unit to validate the interfaces and derive the characterization data provided in the following sections.

TABLE 11-1: TEST CONFIGURATION

Object/Parameter	Description/Setting (Numbers in Decimal)
Acquisition Configuration T8	
CHRGTIME	26
MEASALLOW	11
MEASIDLEDEF	8
MEASACTVDEF	2
Self Test T25	Object Enabled
CTE Configuration T46	
IDLESYNCSPERX	16
ACTVSYNCSPERX	16
Shieldless T56	Object Enabled
INTTIME	26
Lens Bending T65 Instance 0	Object Enabled
Noise Suppression T72	Object Enabled
Glove Detection T78	Object Enabled
Retransmission Compensation T80	Object Enabled
Multiple Touch Touchscreen T100	Object Enabled
XSIZE	12
YSIZE	12
Auxiliary Touch Configuration T104	Object Enabled
Self Capacitance Noise Suppression T108	Object Enabled
Self Capacitance Configuration T111 Instance 0	
INTTIME	60
IDLESYNCSPERL	32
ACTVSYNCSPERL	32
Self Capacitance Configuration T111 Instance 1	
INTTIME	60
IDLESYNCSPERL	32
ACTVSYNCSPERL	32
Self Capacitance Measurement Configuration T113	Object Enabled
Low Power Idle Configuration T126	Object Enabled (and autonomous mode enabled)
SYNCSPERL	17

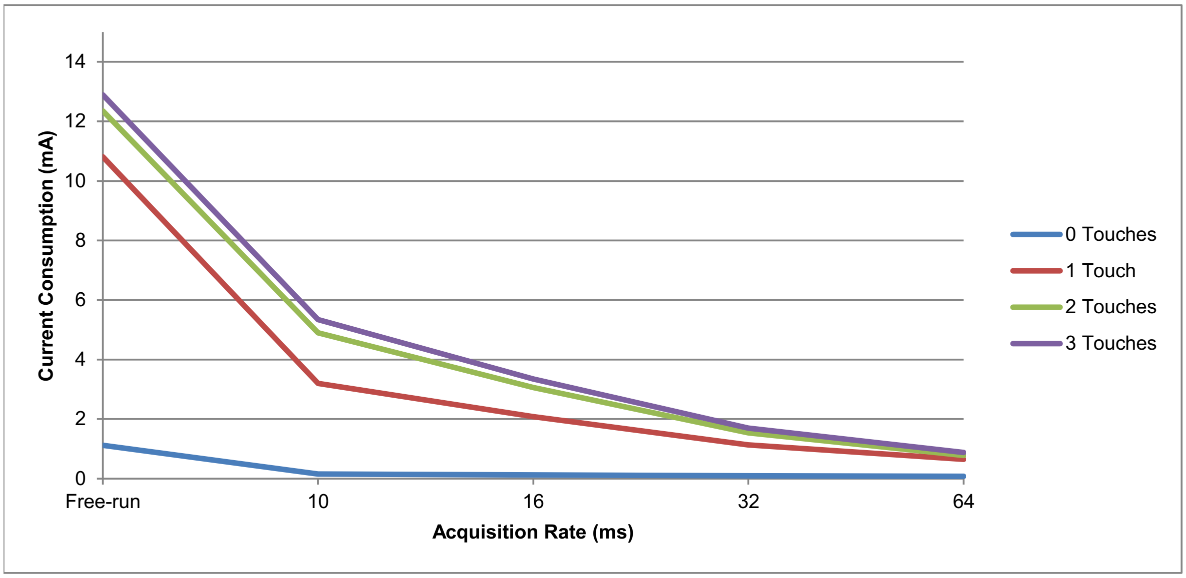
11.4 Supply Current

NOTE The characterization charts show typical values based on the configuration in Table 11-1. Actual power consumption in the user's application will depend on the circumstances of that particular project and will vary from that shown here. Further tuning will be required to achieve an optimal performance.

11.4.1 DIGITAL SUPPLY

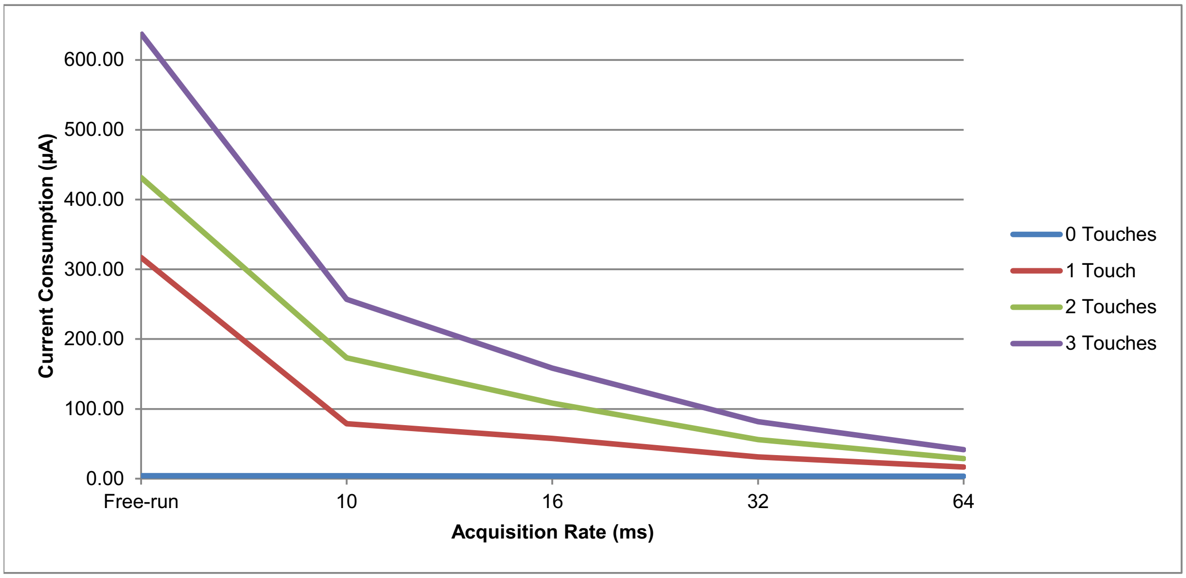
11.4.1.1 Vdd

	Current Consumption (mA)			
Acquisition Rate (ms)	**0 Touches**	**1 Touch**	**2 Touches**	**3 Touches**
Free-run	1.12	10.81	12.35	12.89
10	0.16	3.2	4.9	5.34
16	0.13	2.08	3.06	3.35
32	0.1	1.13	1.54	1.7
64	0.08	0.65	0.78	0.88



11.4.1.2 VddIO

	Current Consumption (µA)			
Acquisition Rate (ms)	**0 Touches**	**1 Touch**	**2 Touches**	**3 Touches**
Free-run	4.21	316.94	431.53	637.72
10	3.98	78.85	172.98	257.16
16	3.71	57.61	108.25	158.53
32	3.69	31.17	55.78	81.79
64	3.46	16.68	28.79	41.59



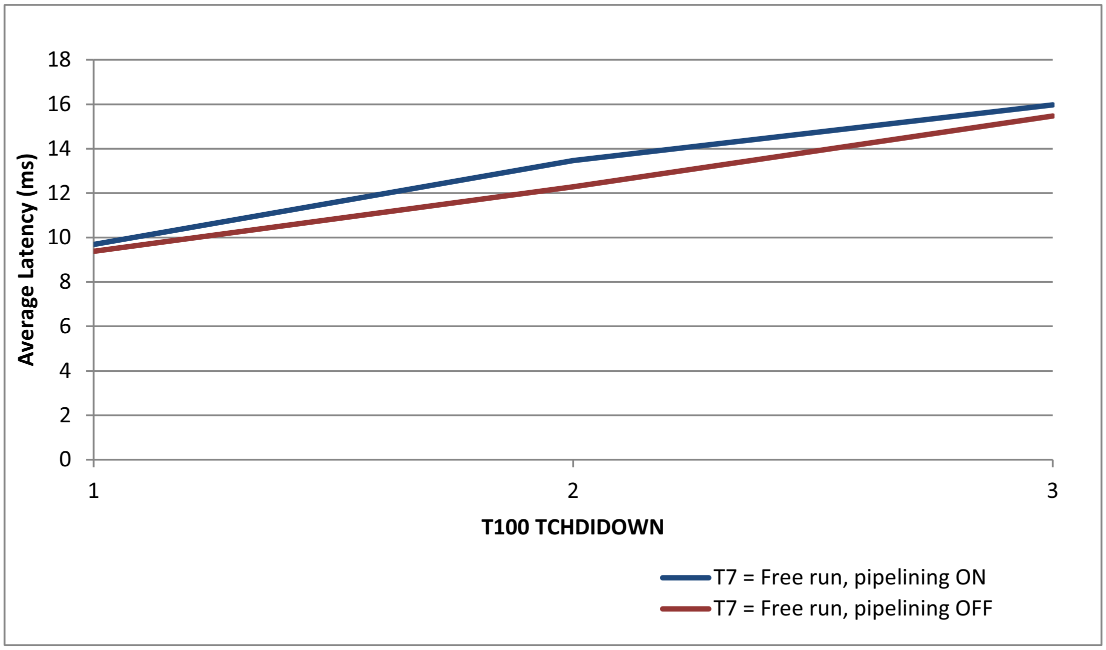
11.4.2 DEEP SLEEP CURRENT

T_A = 25°C

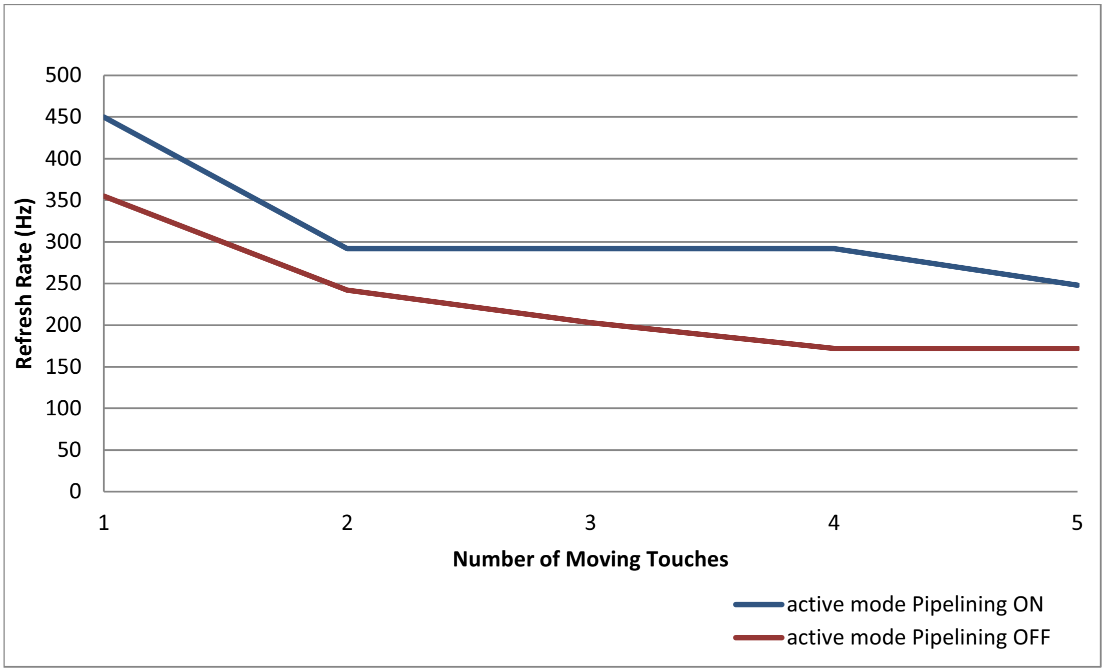
Parameter	Min	Typ	Max	Units	Notes
Deep Sleep Current	–	6.96	–	µA	Vdd = 3.3 V
	–	3.52	–	µA	VddIO = 1.8 V
Deep Sleep Power	–	22.97	–	µW	Vdd = 3.3 V
	–	6.34	–	µW	VddIO = 1.8 V

11.5 Timing Specifications

11.5.1 TOUCH LATENCY



11.5.2 SPEED



11.5.3 RESET TIMINGS

Parameter	Min	Typ	Max	Units	Notes
Power on to $\overline{\text{CHG}}$ line low	–	39	–	ms	Vdd supply for POR VddIO supply for external reset
Hardware reset to $\overline{\text{CHG}}$ line low	–	39	–	ms	
Software reset to $\overline{\text{CHG}}$ line low	–	55	–	ms	

Note 1: Any $\overline{\text{CHG}}$ line activity before the power-on or reset period has expired should be ignored by the host. Operation of this signal cannot be guaranteed before the power-on/reset periods have expired.

11.6 Touchscreen Sensor Characteristics

Parameter	Description	
Cm	Mutual capacitance	Typical value is between –0.3 pF and 10 pF on a single node.
Cpx	Mutual capacitance load to X	Microchip recommends a maximum load of 130 pF on each X or Y line. (1)
Cpy	Mutual capacitance load to Y	
Cpx	Self capacitance load to X	Microchip recommends a maximum load of 130 pF on each X or Y line. (1)
Cpy	Self capacitance load to Y	
∆Cpx	Self capacitance imbalance on X	Nominal value is 14.5 pF. Value increases by 1 pF for every 50 pF reduction in Cpx/Cpy (based on 130 pF load)
∆Cpy	Self capacitance imbalance on Y	

Note 1: Please contact your Microchip representative for advice if you intend to use higher values.

11.7 Input/Output Characteristics

Parameter	Description	Min	Typ	Max	Units	Notes
Input ($\overline{\text{RESET}}$, SDA, SCL, $\overline{\text{CHG}}$)						
Vil	Low input logic level	–0.3	–	0.3 × VddIO	V	VddIO = 1.8 V to Vdd
Vih	High input logic level	0.7 × VddIO	–	VddIO	V	VddIO = 1.8 V to Vdd
Iil	Input leakage current	–	–	1	µA	
$\overline{\text{RESET}}$ pin	Internal pull-up resistor	9	10	16	kΩ	
Output (SDA, SCL, $\overline{\text{CHG}}$, DBG_CLK)						
Vol	Low output voltage	0	–	0.2 × VddIO	V	VddIO = 1.8 V to Vdd Iol = <0.4 mA
Voh	High output voltage	0.8 × VddIO	–	VddIO	V	VddIO = 1.8 V to Vdd Ioh = 0.4 mA
Output (DBG_DATA, $\overline{\text{DBG\_SS}}$)						
Vol	Low output voltage	0	–	0.2 × Vdd	V	Iol = <0.4 mA
Voh	High output voltage	0.8 × Vdd	–	Vdd	V	Ioh = 0.4 mA

11.8 I^{2}C Specification

Parameter	Value
Address	0x4A
I^{2}C specification (1)	Revision 6.0
Maximum bus speed (SCL) (2)	400 kHz
Standard Mode (3)	100 kHz
Fast Mode (3)	400 kHz

Note 1: More detailed information on I^{2}C operation is available from www.nxp.com/documents/user_manual/UM10204.pdf.

2: The values of pull-up resistors should be chosen to ensure SCL and SDA rise and fall times meet the I^{2}C specification. The value required will depend on the amount of capacitance loading on the lines.

3: In systems with heavily laden I^{2}C lines, even with minimum pull-up resistor values, bus speed may be limited by capacitive loading to less than the theoretical maximum.

11.9 Touch Accuracy and Repeatability

Parameter	Min	Typ	Max	Units	Notes
Linearity (touch only; 5.4 mm electrode pitch)	–	±1	–	mm	8 mm or greater finger
Linearity (touch only; 4.2 mm electrode pitch)	–	±0.5	–	mm	4 mm or greater finger
Accuracy	–	±1	–	mm	
Accuracy at edge	–	±2	–	mm	
Repeatability	–	±0.25	–	%	X axis with 12-bit resolution

11.10 Thermal Packaging

11.10.1 THERMAL DATA

Parameter	Description	Typ	Unit	Condition	Package
θ_{JA}	Junction to ambient thermal resistance	43.9	°C/W	Still air	38-pin XQFN 4 × 4 × 0.35 mm
θ_{JC}	Junction to case thermal resistance	14.0	°C/W		38-pin XQFN 4 × 4 × 0.35 mm

11.10.2 JUNCTION TEMPERATURE

The maximum junction temperature allowed on this device is 125°C.

The average junction temperature in °C (T_J) for this device can be obtained from the following:

$$T_J = T_A + (P_D \times \theta_{JA})$$

If a cooling device is required, use this equation:

$$T_J = T_A + (P_D \times (\theta_{HEATSINK} + \theta_{JC}))$$

where:

- θ_{JA}= package thermal resistance, Junction to ambient (°C/W) (see Section 11.10.1 “Thermal Data”)
- θ_{JC} = package thermal resistance, Junction to case thermal resistance (°C/W) (see Section 11.10.1 “Thermal Data”)
- $\theta_{HEATSINK}$ = cooling device thermal resistance (°C/W), provided in the cooling device datasheet
- P_D = device power consumption (W)
- T_A is the ambient temperature (°C)

11.11 ESD Information

Parameter	Value	Reference standard
Human Body Model (HBM)	±2000 V	JEDEC JS–001
Charge Device Model (CDM)	±250 V	JEDEC JS–001

11.12 Soldering Profile

Profile Feature	Green Package
Average Ramp-up Rate (217°C to Peak)	3°C/s max
Preheat Temperature 175°C ±25°C	150 – 200°C
Time Maintained Above 217°C	60 – 150 s
Time within 5°C of Actual Peak Temperature	30 s
Peak Temperature Range	260°C
Ramp down Rate	6°C/s max
Time 25°C to Peak Temperature	8 minutes max

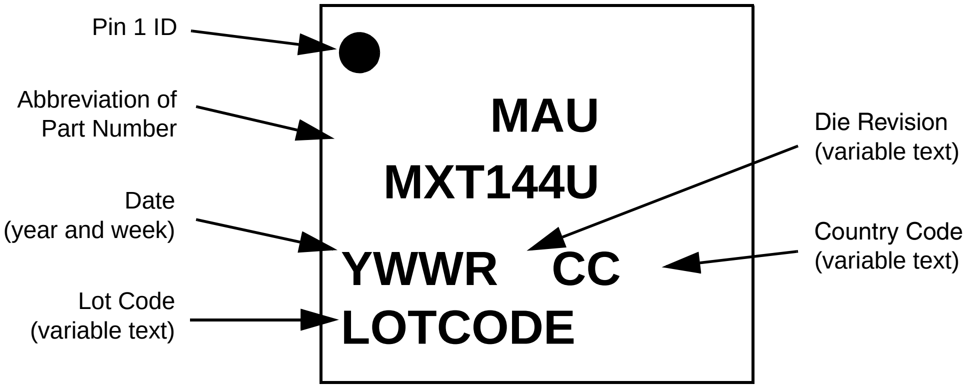
11.13 Moisture Sensitivity Level (MSL)

MSL Rating	Package Type(s)	Peak Body Temperature	Specifications
MSL3	XQFN	260^{o}C	IPC/JEDEC J-STD-020

12.0 PACKAGING INFORMATION

12.1 Package Marking Information

12.1.1 38-PIN XQFN



12.1.2 ORDERABLE PART NUMBERS

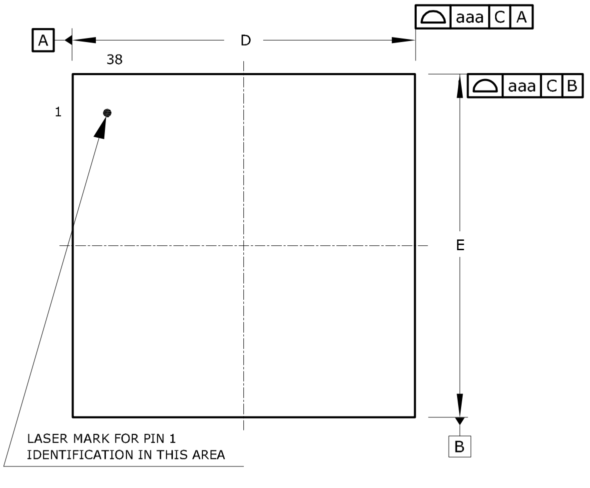
The product identification system for maXTouch devices is described in "Product Identification System". That section also lists example part numbers for the mXT144U device.

12.2 Package Details

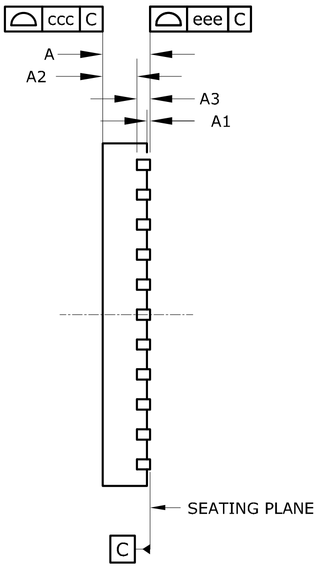
The following section gives the technical details of the package for the device.

12.2.1 38-PIN XQFN 4 × 4 × 0.35 MM

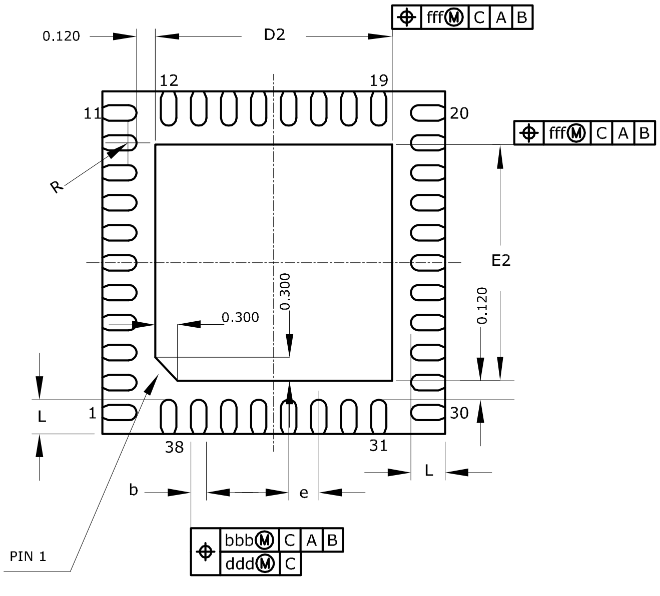
DRAWINGS NOT SCALED



TOP VIEW



SIDE VIEW



BOTTOM VIEW

COMMON DIMENSIONS

(Unit of Measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
A	0.310	0.360	0.400	
A1	0.000	-----	0.050	
A2	-----	0.230	0.280	
A3	0.127 REF			
D/E	4.00 BSC			
D2/E2	2.860	2.960	3.060	
L	0.300	0.400	0.500	
R	0.065	-----	-----	
b	0.130	0.180	0.230	2
e	0.350 BSC			
TOLERANCES OF FORM AND POSITION				
aaa	0.100			
bbb	0.070			
ccc	0.100			
ddd	0.050			
eee	0.080			
fff	0.100			
n	38			

Notes :
1. This drawing is for general information only.
2. Dimension b applies to metallized terminal and is measured between 0.15mm and 0.30mm from the terminal tip.
If the terminal has the optical radius on the other end of the terminal, the dimension should not be measured in that radius area.

10/10/2017

	TITLE	GPC	DRAWING NO.	REV.
	11, 38 Lds - 0.35mm Pitch, 4x4x0.4mm Body size Super Thin Quad Flat No Lead Package (XQFN) Sawn	ZBQ	11	C

APPENDIX A: ASSOCIATED DOCUMENTS

NOTE	Some of the documents listed below are available under NDA only.

The following documents are available by contacting your Microchip representative:

Product Documentation

- Application Note: MXTAN0213 – *Interfacing with maXTouch Touchscreen Controllers*

Touchscreen design and PCB/FPCB layout guidelines

- Application Note: QTAN0054 – *Getting Started with maXTouch Touchscreen Designs*
- Application Note: MXTAN0208 – *Design Guide for PCB Layouts for maXTouch Touch Controllers*
- Application Note: QTAN0080 – *Touchscreens Sensor Design Guide*

Configuring the device

- Application Note: QTAN0059 – *Using the maXTouch Self Test Feature*

Miscellaneous

- Application Note: QTAN0050 – *Using the maXTouch Debug Port*
- Application Note: QTAN0058 – *Rejecting Unintentional Touches with the maXTouch Touchscreen Controllers*
- Application Note: QTAN0061 – *maXTouch Sensitivity Effects for Mobile Devices*

Tools

- *maXTouch Studio User Guide* (distributed as on-line help with maXTouch Studio)

APPENDIX B: REVISION HISTORY

Revision GX (May 2015)

Last released edition for firmware revision 1.0 – Atmel Release version

Revision A (November 2017)

Reformatted edition for firmware revision 1.0.AB – Microchip Release version

This revision incorporates the following updates:

- Updated to Microchip datasheet format:
  - "Pin configuration" moved to start of datasheet
  - "To Our Valued Customers" added
  - Section 12.0 "Packaging Information" updated with new headings. Part numbers moved to "Product Identification System"
  - Associated Documents moved to Appendix A "Associated Documents"
  - Revision History moved to this appendix
  - Index added
  - "Product Identification System" added
  - "The Microchip Web Site", "Customer Change Notification Service" and "Customer Support" sections added
  - Back cover updated
- Features:
  - Typical touchscreen size updated
  - Touch Sensor Technology section added
  - Panel / cover glass support section replaced by Front Panel Material ans specifications upodated
  - Scan Speed one finger reporting rate added
  - Other feature points rearranged
- "Pin configuration": Updated to show power rail information
- Section 1.0 "Overview of mXT144U": Touch detection description updated
- Section 2.0 "Schematic":
  - Schematic modified to show the maximum number of decoupling capacitors required
  - Section 2.2.1 "Power Supply": new section added
  - Section 2.2.2 "Decoupling capacitors": Advice on decoupling capacitors modified to recommend maximum number of decoupling capacitors
  - Section 2.2.3 "Pull-up Resistors": new section added
  - Note section on $\overline{\text{RESET}}$ Line removed; Creset no longer considered optional so note no longer needed
  - Section 2.2.7 "SPI Debug Interface": advice updated
- Section 4.0 "Sensor Layout": Touch panel layout notes updated to aid clarity. Multiple Touch Touchscreen T100 and Key Array T15 rules updated. Section 4.4 "Screen Size" added
- Section 5.0 "Power-up / Reset Requirements": Updated with minor rewording. References to AVdd removed (included in error)
- Section 6.0 "Detailed Operation":
  - Section 6.4 "Sensor Acquisition": Description corrected
  - Section 6.9 "Grip Suppression": Mention of self capacitance grip suppression removed (included in error)
  - Section 6.13 "Adjacent Key Suppression Technology": Updated to remove unnecessary detail
- Section 8.0 "PCB Design Considerations":
  - Section 8.3.3 "Power Supply Decoupling": Advice updated
  - Section 8.4 "Voltage Regulators": section rewritten
  - Table 8-1: Microchip LDOs added
  - I^2C Line Pull-up Resistor section removed; information duplicated elsewhere
  - References to AVdd removed (included in error)

- Section 9.0 “Getting Started with mXT144U”:
  - Section 9.1.2 “Power-up Sequence”: Information and advice corrected
- Section 10.0 “Debugging and Tuning”:
  - Section 10.1 “SPI Debug Interface”: References to AVdd removed (mentioned in error). Information on different power supplies moved to Section 2.2.7 “SPI Debug Interface”
- Section 11.0 “Specifications”:
  - Section 11.1 “Absolute Maximum Specifications”: Maximum junction temperature added
  - Section 11.2 “Recommended Operating Conditions”: Cx parameter removed (replaced by Section 11.6 “Touchscreen Sensor Characteristics”)
  - Section 11.2.1 “DC Characteristics”: Tables updated to show rise/fall rates correctly. Vdd/VddIO supply rise rate corrected to 0.036 V/µs
  - Section 11.2.2 “Power Supply Ripple and Noise” moved
  - Section 11.3 “Test Configuration”: Table 11-1 updated for new characterization data
  - Section 11.4 “Supply Current”: Characterization charts updated. Note added to say characterization charts show typical values. Deep sleep current figures updated
  - Section 11.6 “Touchscreen Sensor Characteristics” added
  - Section 11.7 “Input/Output Characteristics”: All I/O pins are listed in the table.
  - Section 11.8 “I2C Specification”: Specific resistor values removed. Interface speed information added
  - Section 11.10.2 “Junction Temperature”: Maximum junction temperature added
- Appendix A “Associated Documents”: Referenced documents updated
- New orderable part numbers assigned
- maXCharger T72 object renamed to Noise Suppression T72
- Self Capacitance maXCharger T108 object renamed to Self Capacitance Noise Suppression T108
- References to restricted documents removed throughout
- References to Atmel Corporation removed or changed to Microchip Technology Inc, where appropriate
- New documentation number assigned

Revision B (December 2018)

- Section 2.0 “Schematic”: Schematic updated to show Ground on VDDCORE decoupling capacitors (missing in error)

Revision C (April 2019)

- Section 4.3 “Permitted Configurations”: Section added to show permitted sensor configurations

INDEX

PRODUCT IDENTIFICATION SYSTEM

The table below gives details on the product identification system for maXTouch devices. See "Orderable Part Numbers" below for example part numbers for the mXT144U.

To order or obtain information, for example on pricing or delivery, refer to the factory or the listed sales office.

PART NO.	–XXX	[X]	[XX]	[X]	[XXX]
Device	Package	Temperature Range	Sample Type	Tape and Reel Option	Pattern

Device:	Base device name		
Package:	A	=	QFP (Plastic Quad Flatpack)
	CCU	=	UFBGA (Ultra Thin Fine-pitch Ball Grid Array)
	C2U	=	UFBGA (Ultra Thin Fine-pitch Ball Grid Array)
	NHU	=	UFBGA (Ultra Thin Fine-pitch Ball Grid Array)
	C4U	=	X1FBGA (Extra Thin Fine-pitch Ball Grid Array)
	MAU	=	XQFN (Super Thin Quad Flat No Lead Sawn)
	MA5U	=	XQFN (Super Thin Quad Flat No Lead Sawn)
	UU	=	WLCSP (Wafer Level Chip Scale Package)
Temperature Range:	*Blank*	=	–40°C to +85°C (Grade 3)
	T	=	–40°C to +85°C (Grade 3)
	B	=	–40°C to +105°C (Grade 2)
Sample Type:	*Blank*	=	Release Sample
	ES	=	Pre-release (Engineering) Sample
Tape and Reel Option:	*Blank*	=	Standard Packaging (Tube or Tray)
	R	=	Tape and Reel (1)
Pattern:	QTP, SQTP, Code or Special Requirements (Blank Otherwise)		

Note 1: Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. See "Orderable Part Numbers" below or check with your Microchip Sales Office for package availability with the Tape and Reel option.

Orderable Part Numbers

Orderable Part Number	Firmware Revision	Description
ATMXT144U-MAU025 (Supplied in trays)	1.0.AB	38-pin XQFN 4 × 4 × 0.35 mm, RoHS compliant Industrial grade; not suitable for automotive characterization
ATMXT144U-MAUR025 (Supplied in tape and reel)		

THE MICROCHIP WEB SITE

Microchip provides online support via our WWW site at www.microchip.com. This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site contains the following information:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQ), technical support requests, online discussion groups, Microchip consultant program member listing
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